

# Stream Quantification Tool and Debit Calculator

## For the Alaskan Interior

### User Manual (v1.0)



SALCHA-DELTA SOIL AND WATER  
CONSERVATION DISTRICT



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### **User Manual**

June 2021

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U.S. Bureau of Land Management  
U.S. Army Corps of Engineers, Alaska District  
U.S. Environmental Protection Agency  
Alaska Department of Environmental Conservation  
National Park Service  
U.S. Fish and Wildlife Service

#### **Contractors:**

Stream Mechanics  
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#### **Contributing Agencies:**

Alaska Department of Natural Resources  
Alaska Department of Fish and Game  
RESOLVE/ Salmon Gold  
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## Preface

Digital copies of the Stream Quantification Tool and Debit Calculator for the Alaskan Interior (AKSQTint) workbooks and associated documents can be obtained on the Regulatory In-lieu fee and Bank Information Tracking System (RIBITS) website under Assessment Tools for Alaska:

<https://ribits.ops.usace.army.mil/>

A copy may also be requested from any of the USACE Regulatory Office in Alaska.

The following AKSQTint workbooks and documents are available:

- Stream Quantification Tool (SQT) workbook – Microsoft Excel workbook described in detail in this User Manual.
- Debit Calculator workbook – Microsoft Excel workbook described in detail in this User Manual.
- User Manual (this document) – This manual describes the SQT and Debit Calculator workbooks, all calculations performed by the workbooks, and how to collect data and calculate input for the AKSQTint.
- Scientific Support for the AKSQTint – A comprehensive review of the function-based parameters and metrics, reference standards, stratification methods, scoring, and references used in the AKSQTint.

The AKSQTint User Manual was developed using the Colorado Stream Quantification Tool v1.0 User Manual (USACE 2020) as a starting point.

The AKSQTint will be updated and revised periodically as additional data are gathered and reference standards and metrics are refined. The metric that assesses diatoms is considered provisional for use in the Alaskan Interior.

Field data supporting refinement of reference curves and evaluation of metrics are appreciated. The AKSQTint architecture is flexible and future versions of the tool can accommodate additional parameters and metrics. If a user is interested in proposing additional parameters or metrics for incorporation into the tool, they should provide a written proposal for consideration. The written proposal should include a justification and rationale (e.g., data sources and/or literature references) and should follow the framework for identifying reference curves, threshold values, and index scores. Feedback may be submitted at any time to the USACE at [regpagemaster@usace.army.mil](mailto:regpagemaster@usace.army.mil) with subject line of 'SQT Request'.



### ***Disclaimer***

This version of the AKSQTint has been developed for single-thread, wadeable streams in non-glacial alluvial and colluvial valleys in the Alaskan Interior. The tool, including workbooks and supporting documents, is intended for the evaluation of Clean Water Act Section 404 (CWA 404) stream restoration projects and impact sites and their departure from a reference standard in terms of functional lift or loss, respectively. The metrics are scored based on their current condition as compared to a reference standard. Consultation with the local Corps office is recommended prior to the use of this tool related to any CWA 404 activities. In part, or as a whole, the function-based parameters, metrics, and index values are not intended to be used as the basis for engineering design criteria. The U.S. Army Corps of Engineers assumes no liability for engineering designs based on these tools. Designers should evaluate evidence from hydrologic and hydraulic monitoring, modeling, nearby stream morphology, existing stream conditions, sediment transport requirements, and site constraints to determine appropriate restoration design approaches.

## Version

<b><u>AKSQTint Version</u></b>	<b><u>Date finalized</u></b>	<b><u>Description</u></b>
BETA	Feb. 2021	Draft version for review and comment.
1.0	June 2021	Revised in response to agency review; added Alaskan Interior MMI for macroinvertebrates

## Acronyms

**AAC** – Alaska Admin Code  
**AIM** – Assessment, Inventory, Monitoring data from BLM  
**AKSQTint** – Stream Quantification Tool and Debit Calculator for the Alaskan Interior (refers to both the SQT workbook and Debit Calculator workbook)  
**ADEC** – Alaska Department of Environmental Conservation  
**ADF&G** – Alaska Department of Fish and Game  
**AWC** – Anadromous Waters Catalogue  
**BEHI/NBS** – Bank erosion hazard index / near-bank stress  
**BHR** – Bank height ratio  
**BLM** – United States Bureau of Land Management  
**CFP** – Concentrated flow point  
**CFR** – Code of Federal Register  
**Corps** – United States Army Corps of Engineers (also, USACE)  
**CPUE** – Catch per unit effort  
**CWA Section 404** – Section 404 of the Clean Water Act (33 U.S.C. 1344)  
**EPA** – United States Environmental Protection Agency  
**ER** – Entrenchment ratio  
**FF** – Functional feet  
**HUC** – Hydrologic unit code  
**LiDAR** – Light Detection and Ranging  
**LWD** – Large woody debris  
**MMI** – Multi-metric bioassessment index  
**MWR** – Meander width ratio  
**NLCD** – National Land Cover Database  
**NRCS** – Natural Resource Conservation Service  
**NRSA** – National Rivers and Streams Assessment  
**O/E** – Ratio of observed/expected  
**SEM** – Stream Evolution Model  
**SET** – Stream Evolution Triangle  
**SFPF** – Stream Function Pyramid Framework  
**SWCD** – **Soil and Water Conservation District**  
**TMDL** – Total maximum daily load  
**USACE** – United States Army Corps of Engineers (also, Corps)  
**USBLM** – United States Bureau of Land Management (also, BLM)  
**USFWS** – United States Fish and Wildlife Service  
**USGS** – United States Geologic Survey  
**W/D** – Width/depth ratio

## Glossary of Terms

Aerial cover – Aerial cover is defined consistent with the methodology laid out in TR 1735-2 (BLM 2017) and is a visual estimate of the amount of shadow that would be cast by a particular category of vegetation if the sun were directly over the plot area. In other words, a visual estimate of vegetative cover projected down from an aerial view in each category of vegetation (canopy, understory, and groundcover).

Alluvial valley – Refer to definitions for confined alluvial valley and unconfined alluvial valley.

Aufeis – The freezing of water that seeps from the ground, flows from a spring or emerges from beneath a river bed or through fractures in river ice (Woo 2012).

Bankfull – Bankfull is a discharge that forms, maintains, and shapes the dimensions of the channel as it exists under the current climatic regime. The bankfull stage or elevation represents the break point between channel formation and floodplain processes (Wolman and Leopold 1957).<sup>1</sup>

Catchment – Land area draining to the downstream end of the project reach.

Colluvial or V-shaped valleys – Valley formed by the deposition of sediment from hillslope erosion processes. Colluvial valleys are bowl-shaped and typically confined by terraces or hillslopes. Colluvium is material that originates on the hillslopes and moves through mass wasting processes to the valley bottom where the material interacts with stream flow. These valleys are confined and support straighter, step-pool type channels (e.g., A, B, Bc, F). These valley types typically have a valley width ratio less than 7.0 and a meander width ratio (MWR) ratio less than 3. V-shaped valleys are often found in steep gradient headwater valleys.

Confined alluvial valleys – Valley formed by the deposition of sediment from fluvial processes, typically confined by terraces or hillslopes that supports transitional stream types between step-pool and meandering or where meanders intercept hillslopes (e.g., C, Bc). These valley types typically have a valley width ratio less than 7.0 and a meander width ratio (MWR) between 3 and 4.

Condition – The relative ability of an aquatic resource to support and maintain a community of organisms having a species composition, diversity, and functional organization comparable to reference aquatic resources in the region (33 CFR 332.2).

Condition score – Metric-based index values are averaged to characterize condition for each parameter and functional category.

ECS = Existing Condition Score

PCS = Proposed Condition Score

Debit Calculator workbook – The Microsoft-Excel workbook file used to evaluate loss at impact sites.

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<sup>1</sup> The AKSQTint does not require Natural Channel Design restoration approaches. Bankfull can also be referred to as the effective discharge, dominant discharge, or channel forming discharge.

Ephemeral – Surface water flowing or pooling only in direct response to precipitation, such as rain or snow fall (33 CFR 328.3).

Field value – A field measurement or calculation input into the AKSQTint for a specific metric. Units vary based on the metric or measurement method used.

Functional capacity – The degree to which an area of aquatic resource performs a specific function (33 CFR 332.2).

Functions – The physical, chemical, and biological processes that occur in ecosystems (33 CFR 332.2).

Functional category – The organizational levels of the stream quantification tool: Hydrology, Hydraulics, Geomorphology, Physicochemical, and Biology. Each category is defined by a functional statement (Harman et al. 2012).

Functional feet (FF) – Functional feet is the primary unit for communicating functional lift and loss. The functional feet for a stream reach is calculated by multiplying an overall reach condition score by the stream reach length. The change in functional feet ( $\Delta FF$ ) is the difference between the Existing FF and the Proposed FF.

Functional lift – The difference in the condition or functional feet pre- and post-activity, which results in improved function.

Functional loss – The difference in the condition or functional feet pre- and post-activity, which results in a loss of function.

Function-based parameter – A structural measure which characterizes a condition at a point in time, or a process (expressed as a rate) that describes and supports the functional statement of each functional category (Harman et al. 2012).

Geomorphic pools – Large pools that remain intact over time and across a range of flow conditions and are associated with planform features. Examples include pools associated with the outside of a meander bend (streams in alluvial valleys) and downstream of a large cascade or step (streams in colluvial valleys).

Impact severity tier – The Debit Calculator provides estimates of proposed condition based upon the magnitude of proposed impacts, referred to as the impact severity tier. Higher tiers impact more stream functions.

Index values – Dimensionless values between 0.00 and 1.00 that express the relative condition of a metric field value compared with reference standards. These values are derived from reference curves for each metric. Index values are calculated for each metric and then combined to create parameter and functional category scores.

Intermittent – Surface water flowing continuously during certain times of the year and more than in direct response to precipitation (e.g., seasonally when the groundwater table is elevated or when snowpack melts) (33 CFR 328.3).

Measurement method – A specific tool, equation, or assessment method used to inform a metric. Where a metric is informed by a single data collection method, metric and measurement method are used interchangeably (see Metric).

Metric – A specific tool, equation, measured values, or assessment method used to evaluate the condition of a structural measure or function-based parameter. Some metrics can be derived from multiple measurement methods. Where a metric is informed by a single data collection method, metric and measurement method are used interchangeably (see Measurement Method).

Perennial – Surface water flowing continuously year-round (33 CFR 328.3).

Performance standards – Observable or measurable physical (including hydrological), chemical and/or biological attributes that are used to determine if a compensatory mitigation project meets its objectives (33 CFR 332.2).

Permafrost – A thermal condition of surface earth materials that remain below 0°C for two or more years (Muller 1945; Harris et al. 1988). Permafrost includes an active layer at the surface which seasonally thaws in the summer and re-freezes in the fall.

Project area – The geographic extent of a project. This area may include multiple project reaches where there are variations in stream physical characteristics and/or differences in project design approaches.

Project reach – A homogeneous stream reach within the project area, i.e., a stream segment with similar valley morphology, stream type (Rosgen 1996), stability condition, riparian vegetation type, bed material composition, and level of anthropogenic influence. Multiple project reaches may exist in a project area where there are variations in stream physical characteristics and/or differences in project design approaches.

Reference aquatic resources – A set of aquatic resources that represent the full range of variability exhibited by a regional class of aquatic resources as a result of natural processes and anthropogenic disturbances (33 CFR 332.2).

Reference curves – A relationship between observable or measurable metric field values and dimensionless index values. These curves are fitted to threshold values that represent the degree of departure from a reference standard for a given field value. These curves are used to calculate the index value for a given metric at a project site.

Reference standard – The subset of reference aquatic resources that are least disturbed and exhibit the highest level of function. In the AKSQTint, this condition is considered functioning for the metric being assessed, and ranges from least disturbed to pristine condition.

Representative sub-reach – A length of stream within a project reach that is selected for field data collection of most parameters and metrics. The representative sub-reach is typically 20 times the bankfull width or two meander wavelengths (Leopold 1994).

Restoration potential – Restoration potential is the highest level of restoration that can be achieved based on an assessment of the contributing catchment, reach-scale constraints, and the results of the reach-scale function-based assessment (Harman et al. 2012).

Riffle – Riffles are shallow, steep-gradient channel segments typically located between pools. Riffles are the river's natural grade control feature (Knighton 1998) and are sometimes referred to as fast-water channel units (Hawkins et al. 1993; Montgomery and Buffington



1998). For purposes of the AKSQTint, in meandering streams riffles broadly represent the section between lateral-scour pools known as a **crossover**, regardless of bed material size. The term riffle also refers to ripples in sand bed streams and the cascade section of steep mountain streams.

Ripple – Ripples are small-scale bed forms in sand bed channels. As sand accumulates and the size of the ripple grows, it becomes a dune. Other sand-bed forms include plane beds and anti-dunes (Knighton 1998).

Riparian extent – The percentage of the historic or expected riparian area that currently contains riparian vegetation and is free from utility-related, urban, or otherwise soil disturbing land uses, fill, and development.

Riparian vegetation – Plant communities contiguous to and affected by shallow water tables and fluvial disturbance.

Significant pools – All pools, including geomorphic pools, that meet the following criteria (adapted from BLM 2017): Contained within the main channel; contain the thalweg; laterally and longitudinally concave; and span at least 50% of the wetted channel at any location within the pool. Refer to Appendix A for additional guidance on identifying these features.

SQT workbook – The Microsoft-Excel workbook file used to evaluate the change in condition at a project reach. This version of the SQT workbook has been developed for single-thread, wadeable streams in non-glacial alluvial and colluvial valleys in the Alaskan Interior.

Stream Functions Pyramid Framework (SFPF) – The Stream Functions Pyramid is comprised of five functional categories stratified based on the premise that lower-level functions support higher-level functions and that they are all influenced by local geology and climate. The SFPF includes the organization of function-based parameters, metrics (measurement methods), and performance standards to assess the functional categories of the Stream Functions Pyramid. (Harman et al. 2012)

Stream restoration – The manipulation of the physical, chemical, or biological characteristics of a site with the goal of returning natural/historic functions to a former or degraded aquatic resource (33 CFR 332.2). The term is used more broadly in this document to represent stream compensatory mitigation methods including establishment, re-habilitation, re-establishment, and enhancement as defined in the 2008 Compensatory Mitigation for Losses to Aquatic Resources; Final Rule (2008 Rule) (USACE/EPA 2008).

Threshold values – Criteria used to develop the reference curves and index values for each metric. These criteria differentiate between three condition categories: functioning, functioning-at-risk, and not-functioning and relate to the Performance Standards defined in Harman et al. (2012).

Unconfined alluvial valleys – Wide, low gradient (typically less than 2% slope) valleys that support meandering and anastomosed stream types (e.g., C, E, D<sub>A</sub>). In alluvial valleys, rivers adjust pattern without intercepting hillslopes. These valleys typically have a valley width ratio greater than 7.0 (Carlson 2009) or a meander width ratio (MWR) greater than 4.0 (Rosgen 2014).

## Purpose and Use of the AKSQTint

This version of the Stream Quantification Tool and Debit Calculator for the Alaskan Interior (AKSQTint) have been regionalized for single-thread, wadeable streams in non-glacial alluvial and colluvial valleys. The purpose of the AKSQTint is to **calculate functional lift and loss associated with reach-scale stream restoration and impact activities**. The tool is a calculator that quantifies change between an existing and future stream condition. A main goal of the AKSQTint is to produce **objective, verifiable, and repeatable results** by consolidating well-defined procedures for quantitative measures of structural or compositional attributes of a stream and its underlying processes.

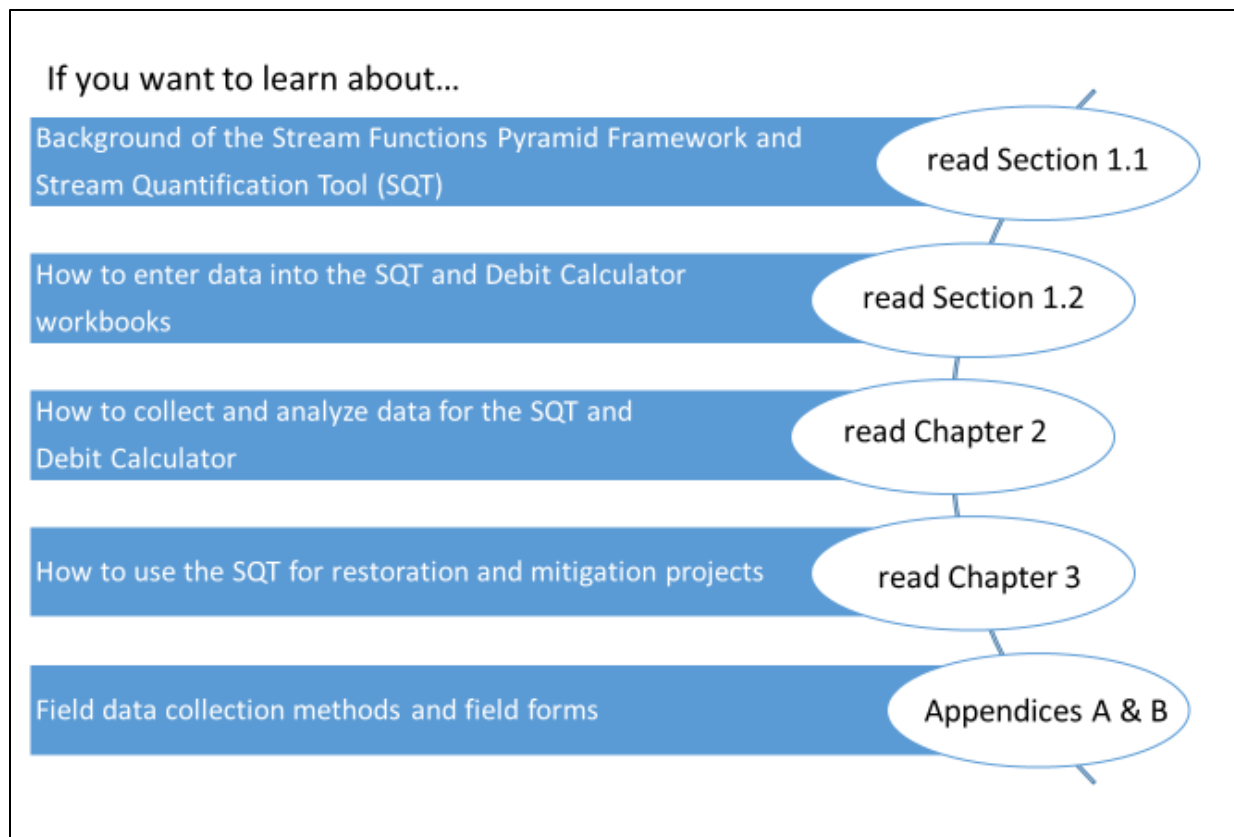
On the restoration side, functional change can be estimated during the design or mitigation plan phase and verified during post-construction monitoring events using the Stream Quantification Tool (SQT) workbook. The 2008 Compensatory Mitigation for Losses to Aquatic Resources; Final Rule (2008 Rule; USACE/EPA 2008) defines **stream restoration** as the manipulation of the physical, chemical, or biological characteristics of a site with the goal of returning natural/historic functions to a former or degraded aquatic resource (33 CFR 332.2). The term is used more broadly in this document to represent compensatory mitigation methods including establishment, re-habilitation, re-establishment, and enhancement as defined in the 2008 Rule (USACE/EPA 2008).

On the impact side, functional change can be estimated several ways using the **Debit Calculator workbook**. This workbook is separate from the **SQT workbook** but uses the same **metrics** and scoring methodology (Section 1.2.8).

One of the purposes of the AKSQTint is to ensure parity between debits and credits. These function-based tools are designed to ensure that functional losses are fully offset or mitigated with function-based credits.

Not all portions of the SQT or Debit Calculator workbooks will be applicable to all projects. Figure 1 can assist in navigating the User Manual for specific project types.

The SQT workbook can also help determine if a proposed site has the potential to be considered for a stream restoration or mitigation project and provides a framework to guide restoration planning. The **catchment** assessment and **restoration potential** process accompanying the SQT (described in Chapter 3) can be used to help determine factors that may limit what can be achieved by a stream restoration project. This information can be used to develop project goals that match the restoration potential of a site. Quantifiable objectives, **performance standards**, and monitoring plans can be developed that link restoration activities to measurable changes in functional-category condition and **function-based parameters** assessed by the tool.



*Figure 1: Manual Directory*

### **Key Considerations**

The AKSQTint and supporting documentation have been developed primarily for use in regulatory programs, such as CWA 404, to meet the function-based approaches set forth in the 2008 Rule (USACE/EPA 2008). Therefore, the following concepts are critical in understanding the applicability and limitations of this tool:

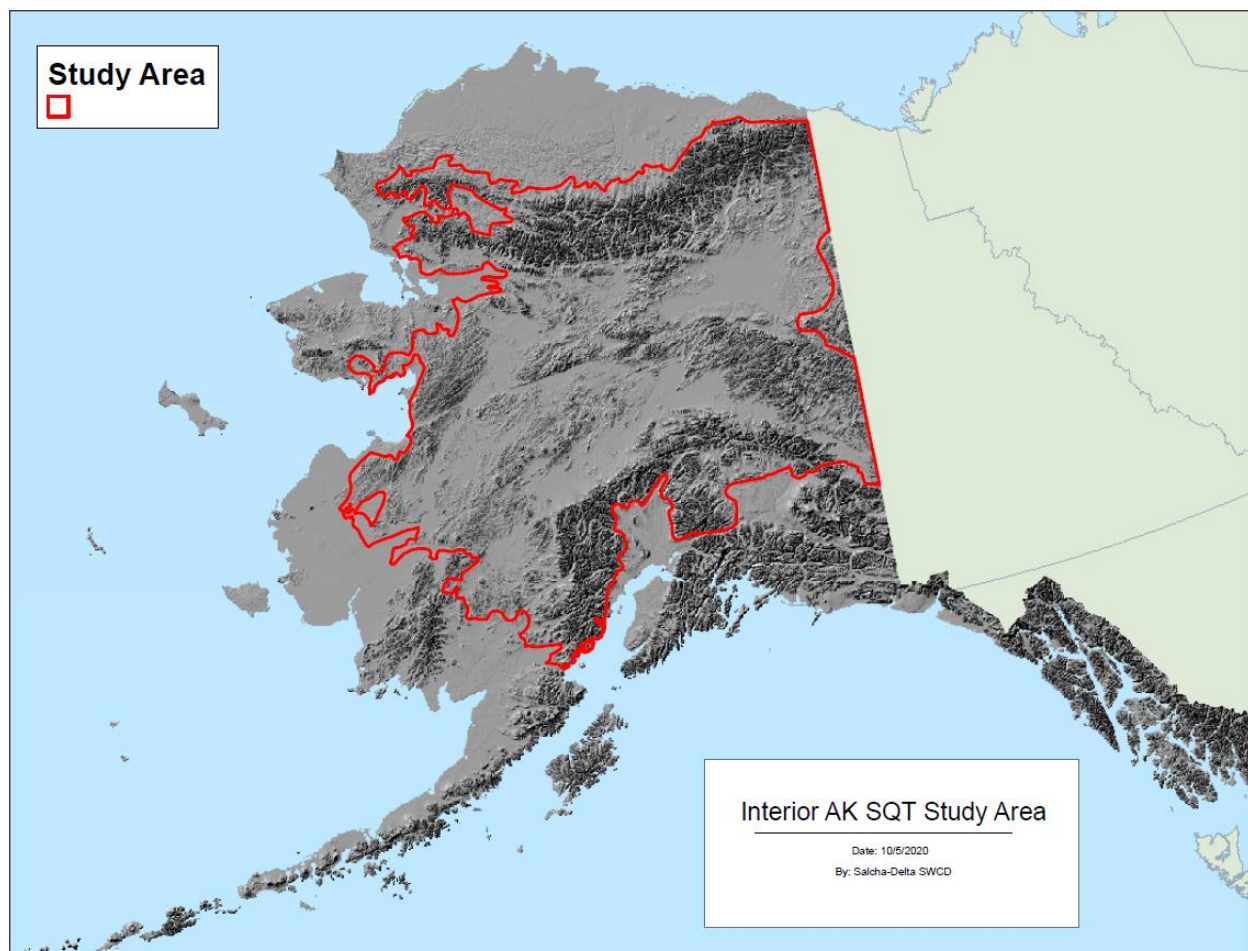
- The parameters and metrics in the tool were, in part, selected due to their sensitivity in responding to reach-scale changes associated with the types of activities commonly used in stream restoration and commonly encountered impacts in the region. These parameters are not intended to comprehensively characterize all structural measures or processes that occur within a stream; especially if the reach is not assessed through Level 5, Biology.
- The AKSQTint is designed to assess the same metrics at a site pre- and post-activity to provide information on the degree to which the **condition** of the stream system changes following impacts or restoration activities. Unless the same parameters and metrics are used across all sites, it would not be appropriate to compare scores across sites.
- The AKSQTint itself does not score or quantify watershed condition. Watershed condition reflects the external elements that influence functions within a **project reach** and may affect project site selection or the restoration potential of a site (see Chapter 3). However, the SQT

does qualitatively assess watershed condition and stressors that may limit restoration potential.

- The AKSQTint is not a design tool. There may be more appropriate function-based parameters and analyses which are critical to a successful restoration design but sit outside of the scope of the AKSQTint. The AKSQTint instead measures the hydraulic, geomorphological, and ecological responses or outcomes related to a reach-scale project.
- The AKSQTint is a reach-based tool that assesses the stream channel, adjacent floodplain, expected **riparian extent**, and the lateral drainage area. It is not solely an in-channel assessment method even though the unit of measure is **functional feet**.
- The AKSQTint uses functional feet as the unit of measure applied to the reach **condition score** after the condition assessment of the channel, floodplain, riparian extent, and lateral drainage area has been assessed and scored. This unit of measure provides scale to an otherwise unitless measure, which can be used in the debit and credit determination method.

## Chapter 1. Background and Introduction

This version of the Stream Quantification Tool and Debit Calculator for the Alaskan Interior (AKSQTint) consists of two spreadsheet-based calculators, the SQT workbook and Debit Calculator workbook. These tools have been regionalized for use in **single-thread, wadeable streams in non-glacial alluvial and colluvial valleys** in the Alaskan Interior (Figure 2). The SQT and Debit Calculator Excel workbooks have been developed to evaluate a suite of metrics that represent structural or compositional attributes of a stream and its underlying processes. Metrics in the AKSQTint represent parameters that are often impacted by authorized projects or affected (e.g., enhanced or restored) by restoration actions. As such, the AKSQTint is not intended as a comprehensive assessment of stream **function**. The AKSQTint is an application of the Stream Functions Pyramid Framework (SFPF; Harman et al. 2012) and uses function-based parameters and metrics to assess five **functional categories**: hydrology, hydraulics, geomorphology, physicochemical, and biology.



**Figure 2: Alaskan Interior for AKSQTint Regionalization**

The AKSQTint includes 28 metrics within 14 parameters that can be evaluated at a project site. This User Manual provides methods for collecting and processing data related to each metric, as well as direction for selecting which parameters and metrics to evaluate at a project site. Teams collecting and analyzing these data should have experience and expertise in botany, aquatic ecology, hydrology, and geomorphology as well as experience and expertise applying the assessment methods used to calculate the metrics included in the SQT and Debit Calculator workbooks. **Interdisciplinary teams of at least two people with a combination of these skill sets are necessary to ensure consistent and accurate data collection and analyses.**

The same parameters and metrics within all five functional categories are included in the Debit Calculator workbook to ensure that the debit captures an appropriate amount of functional loss. The field methods for assessing the parameters and metrics are the same between the SQT and Debit Calculator. To ensure that the flexibility in selecting parameters and metrics during the stream restoration/mitigation process does not create a disparity with debit calculations, the debit tool always calculates a condition and functional-foot score through all five functional categories.

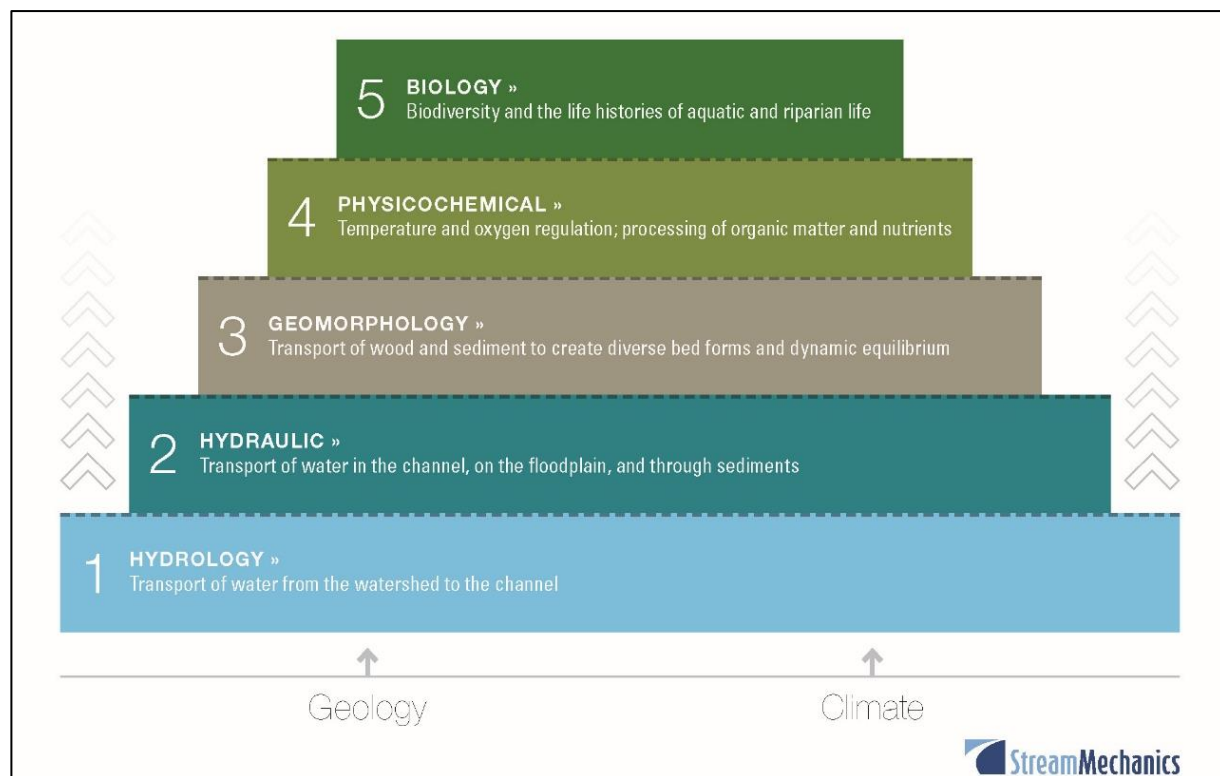
This manual describes the SQT and Debit Calculator workbooks, including how to collect, analyze and input data. Companion documents include the Scientific Support for the AKSQTint (Steering Committee 2021), which provides rationales for the scoring used in the AKSQTint and describes how measured stream conditions were converted into dimensionless index scores. Debit and credit determination methods are not included in this manual. Users are strongly encouraged to contact the Corps, or the appropriate regulatory entity, to obtain project-specific guidance before applying the AKSQTint.

Other stream quantification tools and user manuals have also been developed for use in other states, including Colorado (USACE 2020), Wyoming (WSTT 2018), North Carolina (Harman and Jones 2017a,b), Tennessee (TDEC 2018), Georgia (USACE 2018), and Minnesota (MNSQT SC 2019).

## 1.1 Stream Functions Pyramid Framework (SFPF)

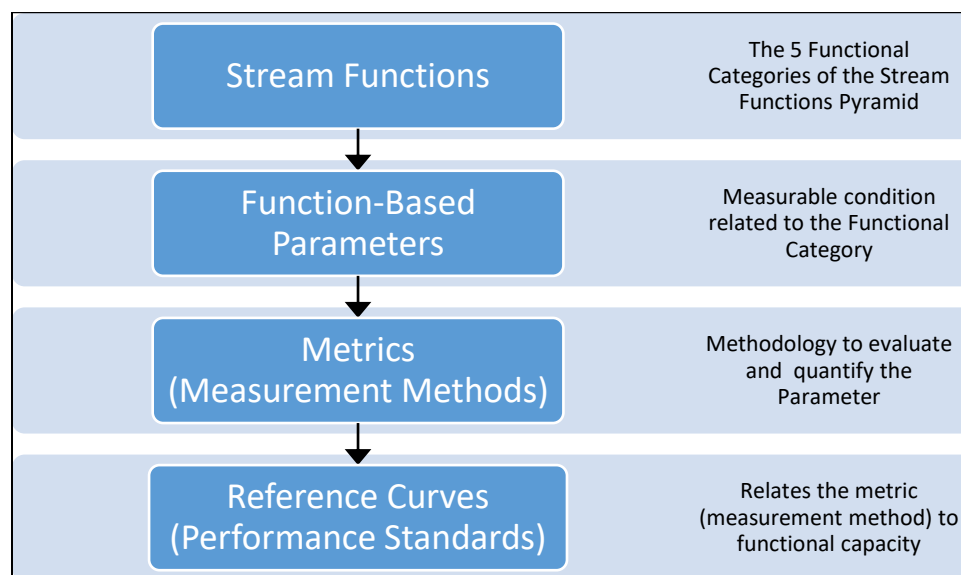
The AKSQTint is an application of the Stream Functions Pyramid Framework (SFPF). The Stream Functions Pyramid (Figure 3) includes five functional categories: Level 1: Hydrology, Level 2: Hydraulics, Level 3: Geomorphology, Level 4: Physicochemical, and Level 5: Biology. The organization of the Stream Functions Pyramid asserts that lower-level functions generally support higher-level functions (although the opposite can also be true) and that all functions are influenced by local geology and climate. Each functional category is defined by a functional statement as shown in Figure 3.





*Figure 3: Stream Functions Pyramid (Image from Harman et al. 2012)*

The SFPF illustrates a hierarchy of stream functions but does not provide specific mechanisms for addressing **functional capacity**, establishing performance standards, or communicating functional change. The diagram in Figure 4 expands the Pyramid concept into a more detailed framework to quantify functional capacity, establish performance standards, evaluate functional change, and establish function-based goals and objectives.



*Figure 4: Stream Functions Pyramid Framework*

The SFPF details forms of analysis to quantify stream functions and functional indicators of underlying stream processes. In this framework, function-based parameters describe and support the functional statements of each category, and metrics (**measurement methods**) are specific tools, equations, and/or assessment methods used to characterize site condition and inform function-based parameter scores. Performance standards are measurable or observable end points of stream restoration.

## 1.2 Stream Quantification Tool and Debit Calculator

A main goal of the AKSQTint is to produce objective, verifiable, and repeatable results by consolidating well-defined procedures for quantitative measures of structural or compositional attributes of a stream and its underlying processes. This version of the AKSQTint is regionalized for use in single-thread, wadeable streams in non-glacial alluvial and colluvial valleys in the Alaskan Interior.

The SQT workbook ('AKSQTint\_SQT v1.xlsx') is a Microsoft Excel Workbook comprised of 8 worksheets. This workbook can be used to calculate functional change and track monitoring events within a project reach. There are no macros in the workbook and all formulas are visible, though some worksheets are locked to prevent editing. One workbook should be assigned to each project reach within a **project area**. Each of the following worksheets is described in this Section:

- Project Assessment
- Catchment Assessment
- Metric Selection Guide
- Quantification Tool (locked)
- Monitoring Data (locked)
- Data Summary (locked)
- Reference Curves (locked)
- Pull Down Notes – This worksheet is hidden and contains all the inputs for drop down menus throughout the workbook.

The Debit Calculator workbook ('AKSQTint\_Debit Calculator v1.xlsx') is a Microsoft Excel Workbook comprised of 7 worksheets. This workbook provides a simplified approach to calculate functional loss (debits) in a project reach. There are no macros in the workbook and all formulas are visible, though some worksheets are locked to prevent editing. One workbook can accommodate up to ten project reaches within a project area. Each of the following worksheets is described in this Section:

- Project Assessment
- Catchment Assessment
- Debit Calculator (locked)
- Existing Conditions (locked) – used for debit options 1 and 2.
- Proposed Conditions (locked) – used for debit option 1 only.
- Reference Curves (locked) – This worksheet is hidden and contains only the coefficients used to calculate **index values**. **Reference curves** are shown in the SQT workbook and the Scientific Support for the AKSQTint (Steering Committee 2021).
- Pull Down Notes – This worksheet is hidden and contains all the inputs for drop-down menus throughout the workbook.

The AKSQTint includes function-based parameters and metrics selected by the Steering Committee to quantify stream condition across the ecoregions and wadeable stream types found in the Alaskan Interior. Each metric is linked to reference curves that relate measured **field values** to a **reference aquatic resource** condition. In the AKSQTint, field values for a metric are assigned an index value (0.00 – 1.00) using the applicable reference curves. The numeric index value range is standardized across metrics by determining how field values relate to functional capacity, i.e., functioning, functioning-at-risk, and not-functioning conditions (Table 1). The reference curves in the AKSQTint are tied to specific benchmarks (thresholds) that represent the degree to which the aquatic resources are functioning and/or the degree to which the condition departs from the **reference standard**.

#### Calculating Change in Condition

It is important to remember, that the primary purpose of the AKSQTint is to compare pre- and post-project conditions at a site. As such, the **difference** between existing and future site conditions is the most important element, more important than the reach-scale condition value.

Reference curves are used to relate point-in-time condition measurements to functional capacity and standardize all metrics to an ecologically relevant scale.

**Table 1: Functional Capacity Definitions Used to Define Threshold Values and Develop Reference Curves for the AKSQTint**

Functional Capacity	Definition	Index Score Range
Functioning	A functioning value means that the metric is quantifying the functional capacity of one aspect of a function-based parameter in a way that <b>is anticipated to support aquatic ecosystem structure and function</b> . A score of 1.00 represents an unaltered or pristine condition (native or natural condition). The range of values defined as functioning (0.70-1.00) accounts for natural variability in reference standard datasets and the potential for reference standard datasets to include least disturbed sites.	0.70 to 1.00
Functioning-at-risk	A functioning-at-risk value means that the metric is quantifying one aspect of a function-based parameter in a way that <b>partially supports aquatic ecosystem structure and function</b> , but not at a reference standard. In many cases, this indicates the parameter is adjusting in response to changes in the reach or the <b>catchment</b> towards lower or higher function.	0.30 to <0.70
Not-functioning	A not-functioning value means that the metric is quantifying one aspect of a function-based parameter in a way that <b>is not anticipated to support aquatic ecosystem structure and function</b> . An index value less than 0.29 represents an impaired or severely altered condition relative to the reference standard condition, and an index value of 0.00 represents a condition that provides no functional capacity for that metric.	0.00 to <0.30

### 1.2.1 Project Assessment Worksheet

The Project Assessment worksheet allows for a description of the project reach, the purpose of the project, and other information. This worksheet is included in both the SQT workbook and the Debit Calculator workbook, but contains different components, as described below.

For projects with multiple reaches (and thus multiple workbooks), the project information on this worksheet may be the same across workbooks except for a unique reach-specific description. Information on delineating project reaches is provided in Chapter 2.

#### **Components of the Project Assessment Worksheet**

To complete the Project Assessment worksheet, users will need to complete the following components for each project reach.

Programmatic Goals (SQT workbook only) – Programmatic goals represent big-picture goals that are often broader than function-based goals and are determined by the project proponent or funding entity. A drop-down menu is provided with the following options: Mitigation – Credits, Mitigation – Debits, Non-mitigation, or Other.

Reach Description (SQT and Debit Calculator workbooks) – In the SQT workbook, space is provided to describe the project reach, including the individual reach ID and location (latitude/longitude). Reach break criteria is described in Section 2.1.

- In the SQT workbook, the reference stream type for the reach is also entered along with a narrative explanation of how the reference stream type was determined. Reference stream type is a drop-down menu selection. Direction for selecting the reference stream type is provided in Section 2.2.
- In the Debit Calculator workbook there is space for up to 10 project reaches to be assessed in the same workbook. The introductory table for the reaches assessed within the workbook asks the user to identify the reference or proposed Strahler stream order and flow type, and a description of the reach and proposed impact activities. Stream order and flow type provide context to the change in functional feet. Both of these are described in Section 2.4. The explanatory text describing the reach and impact should describe the current condition and anticipated impacts to aquatic ecosystem functions and parameters within the project reach.

Aerial Photograph of Project Reach/Area (SQT and Debit Calculator workbooks) – Provide a current aerial photograph of the project reach or project area. The photo should include labels indicating where work is proposed, the project area boundaries or easement, and any important features within the project site (e.g., reach breaks, representative reach location, cross-section locations, etc.).

Restoration Approach (SQT workbook only) – There are three boxes for the user to explain programmatic goals, discuss restoration potential, and define project goals and objectives (see Example 1).

Box 1 provides space for the user to expand on the programmatic goals of the project.

Box 2 should be used to explain the connection between the restoration potential and the programmatic goals. The restoration potential can be classified as partial or full restoration, refer to Section 3.2.

Finally, Box 3 should be used to describe the function-based goals and objectives of the project.

More information on restoration potential and developing goals and objectives is provided in Chapter 3.

#### ***Example 1: Restoration Approach***

If the programmatic goal is to create mitigation credits, then the first text box could provide more information about the type and number of credits desired.

If the restoration potential is partial restoration, then the second text box would explain how improvements to hydrology, hydraulics, and/or geomorphology would create the necessary credits and identify whether there are constraints that may limit restoration of physicochemical and biological functions to a reference standard.

In the third box, the goals of the project would match the restoration potential, e.g., target reference standard habitat condition and partial restoration of biology functions. Goals are accompanied by objectives that identify parameters to be restored and which metrics will be used to monitor restoration progress.

### 1.2.2 Catchment Assessment Worksheet

The Catchment Assessment worksheet is present in both the SQT and Debit Calculator workbooks. This worksheet assists in characterizing watershed processes and stressors that exist outside of the project reach but affect functions and processes within the reach. This information provides context for the hydrologic, physicochemical and biological existing conditions. It also highlights factors necessary to consider or address during the project design to maximize the likelihood of a successful project.

Space is provided on the form to list the applicable reach(es) within the project area. This is for project areas with multiple reaches but the same, or a similar, **catchment**. For a project reach where the Catchment Assessment has been completed in a separate Excel workbook, provide the file name for the completed form.

Space is also provided to list the HUC 8 watershed name and number.

This worksheet contains 13 pre-defined categories and an optional, blank category (Other) to be rated as Good, Fair, or Poor. Most of the categories describe potential stressors upstream of the project reach since the contributing catchment influences the hydrology, water quality, and biological condition within the project reach. However, there are a few categories, such as barriers/fish passage, that consider influences both upstream and downstream of the project reach.

Based on the category ratings, the user should provide an overall watershed condition and describe how any of the categories rated as poor were considered in the selection of restoration potential. Detailed guidance on data collection and rating the 14 categories is provided in Section 2.3.

### 1.2.3 Metric Selection Guide Worksheet

This worksheet is included in the SQT workbook, but not the Debit Calculator workbook.

The Metric Selection Guide worksheet assists users in selecting the appropriate parameters and metrics for each project reach. All parameters and metrics would rarely, if ever, be used for a single project. The scenarios on the sheet show when each parameter and metric should be used and summarizes the information provided in Section 2.5 of this manual. Note, if a metric is selected, it must be assessed for the existing condition, proposed condition, and all subsequent monitoring events.

The metric that assesses diatoms is considered provisional for use in the Alaskan Interior; refer to Section 2.10.3 for more information.

### 1.2.4 Quantification Tool, Existing Conditions, and Proposed Conditions Worksheets

The Quantification Tool worksheet is included in the SQT workbook. The Debit Calculator workbook includes separate worksheets for entering existing and proposed condition



information for up to 10 reaches, called the Existing Condition and Proposed Condition worksheets, respectively.

- SQT workbook – The Quantification Tool worksheet contains three areas for data entry: Site Information and Reference Selection, Existing Condition Assessment field values, and Proposed Condition Assessment field values.
- Debit Calculator workbook – The Existing Condition and Proposed Condition worksheets have space to enter data for up to 10 project reaches. The Site Information and Reference Selection data for each reach can be entered onto the Existing Conditions worksheet and this information is automatically populated on the Proposed Conditions worksheet. Both worksheets contain data entry areas for field values that describe reach conditions.

Cells that allow input are shaded gray and all other cells are locked. Each section of the worksheet is discussed below.

### ***Site Information and Reference Selection***

The Site Information and Reference Selection section consists of general site information and classifications to determine which reference curve(s) to apply in calculating index values for relevant metrics. Figure 5 shows the Site Information and Reference Selection section from the Quantification Tool worksheet within the SQT workbook. The Debit Calculator worksheets contain only a subset of the inputs shown in Figure 5; those that are required for reference curve stratification. Information on each input field and guidance on how to select/calculate values is provided in Section 2.4. In both workbooks, information entered on the Project Assessment worksheet (e.g., Reach ID) will auto-populate in the Site Information and Reference Selection section.

**Note that incorrect information in the Site Information and Reference Selection section may result in applying reference curves that are not suitable for the project.**

<b>Site Information and Reference Selection</b>	
Project Name:	Example
Reach ID:	UT1
Restoration Potential:	Partial
Existing Stream Length (ft):	1000
Proposed Stream Length (ft):	1000
Existing Stream Type:	C
Reference Stream Type:	C
Valley Type:	Unconfined Alluvial
Drainage Area (sq.mi.):	5
Strahler Stream Order:	3
Flow Type:	Perennial
Proposed Bed Material:	Gravel
Proposed Slope (%):	1
Ecoregion:	Interior Forested Lowlands/Uplands
Fish Assemblage:	Non-anadromous
Reference Vegetation Cover:	Forested

**Figure 5: Example Site Information and Reference Selection Input Fields**

### **Existing and Proposed Condition Assessment Data Entry**

Once the Site Information and Reference Selection section has been completed, the user can input data into the field value column of the Condition Assessment tables (Figure 6). Note, in the Debit Calculator workbook, these tables are contained in two separate worksheets: Existing Condition and Proposed Condition worksheets, which include space to enter data for up to 10 project reaches.

A user will rarely input data for all metrics or parameters within the tool. Guidance on parameter selection is provided in Section 2.5. The function-based parameters and metrics are listed by functional category, starting with Hydrology. Multiple tables in the AKSQTint are color-coded to show the delineation between functional categories: light blue for hydrology, blue for hydraulics, orange for geomorphology, yellow for physicochemical, and green for biology.

Function-Based Parameter	Metric	Field Value
Catchment Hydrology	Land Use Coefficient	
	Impervious Cover (%)	2
	Anthropogenic Land Cover (%)	50
Reach Runoff	Land Use Coefficient	22
	Impervious Cover (%)	
	Anthropogenic Land Cover (%)	
	Concentrated Flow Points (#/1,000ft)	2
Floodplain Connectivity	Bank Height Ratio (ft/ft)	1.3
	Entrenchment Ratio (ft/ft)	1.8
Flow Dynamics	Width/Depth Ratio (% of Expected)	70
Large Woody Debris (LWD)	LWD Frequency (#/100m)	3
Lateral Migration	Dominant BEHI/NBS	H/VH
	Percent Streambank Erosion (%)	56
	Percent Streambank Armoring (%)	
Bed Material Characterization	Percent Fines < 2mm (%)	28
Bed Form Diversity	Pool Spacing Ratio (ft/ft)	1
	Pool Depth Ratio (ft/ft)	1
	Percent Riffle (%)	100
Riparian Vegetation	Riparian Extent (% of Expected)	10
	Vegetative Complexity	0.5
	Native Cover (%)	
Temperature	Daily Maximum Temperature (O/E)	1.2
Turbidity	Daily Average Turbidity (O/E)	8
Diatoms	Diatom Index	
Macroinvertebrates	Alaskan Interior MMI	59
Fish	Fish Species Richness (% of Expected)	0
	Relative Abundance (O/E)	0
	Species Biomass (O/E)	0

**Figure 6: Example Field Value Data Entry in the Condition Assessment Table**

The Existing Condition Assessment field values are derived from data collection and analysis methods outlined in Chapter 2. An existing condition score (ECS) relies on baseline data collected from the project reach before any work is completed.

The Proposed Condition Assessment field values should consist of reasonable values for restored or impacted conditions. For the Proposed Condition Assessment, the user should rely on available data to estimate proposed condition field values. Proposed field values that describe the physical post-project condition of the stream reach should be based on project design studies and calculations, drawings, field investigations, and best available science. Proposed condition field values should be appropriate for the setting, stream type, and watershed conditions within the project area; consistent with the process drivers and restoration potential of the site; and representative of the site conditions likely to occur at the end of an

established monitoring period. Refer to relevant metric sections in Chapter 2 for additional information.

The same parameters and metrics must be used for the existing and proposed condition assessments. Therefore, field values for the proposed post-project condition must be determined for all metrics used to assess the existing stream reach.

### Scoring Functional Lift and Loss

Scoring occurs automatically as field values are entered into the Existing Condition Assessment or Proposed Condition Assessment tables. A field value will correspond to an index value ranging from 0.00 to 1.00 for that metric. Where more than one metric is used per parameter, these index values are averaged to calculate parameter scores. Similarly, multiple parameter scores within a functional category are averaged to calculate functional category scores. Functional category scores are weighted and summed to calculate functional change.

**Index Values** – The reference curves available for each metric are visible in the Reference Curves worksheet of the SQT workbook. When a field value is entered for a metric in a condition assessment, these reference curves are used to calculate an index value.

As a field value is entered in the Quantification Tool worksheet, the neighboring index value cell should automatically populate with an index value (Example 2a). If the index value cell returns FALSE instead of a numeric index value, the Site Information and Reference Selection section may be missing data (Example 2b).

#### Example 2: Populating Index Values in AKSQTint

(a) Index values automatically populate when field values are entered.

Metric	Field Value	Index Value
Pool Spacing Ratio (ft/ft)	5	1.00
Pool Depth Ratio (ft/ft)	1.2	0.12
Percent Riffle (%)	30	0.54

(b) If FALSE, check the Site Information and Reference Selection section of the worksheet.

Metric	Field Value	Index Value
Pool Spacing Ratio (ft/ft)	5	FALSE
Pool Depth Ratio (ft/ft)	1.2	0.12
Percent Riffle (%)	30	FALSE

If the worksheet does not return a numeric index value, the user should check the Site Information and Reference Selection for data entry errors and then check the stratification for the metric in the Reference Curve worksheet. Note that incorrect information in the Site Information and Reference Selection section may result in applying reference curves that are not suitable for the project.

**Scoring** – In the AKSQTint, scores are averaged within each functional category. Metric index values are averaged to calculate parameter scores and parameter scores are averaged to calculate category scores (Figure 7). There are two exceptions to this scoring in the AKSQTint: floodplain connectivity and lateral migration.

- The width/depth ratio (W/D) metric captures problems associated with aggradation (W/D is larger than reference value) and incision (W/D is less than reference value). Note that a W/D that is smaller than the reference W/D is only a problem if the channel is incised as indicated

by the bank height ratio (BHR). When the percent of the expected W/D of less than 100 is entered into the SQT, the index value calculation will check whether the BHR is greater than 1.2. If BHR is greater than 1.2 then the reference curve will be used to calculate the index value. If BHR is less than or equal to 1.2, then the W/D index value is set to 1.00.

- There are three metrics for lateral migration, including a metric that reflects the amount of artificial bank hardening present (percent armoring; refer to Section 2.5 for direction on metric selection). Where percent armoring exceeds 50% of the total bank length, the parameter as a whole will score a 0.00 regardless of any other metric field values entered.

Category scores are weighted and summed to calculate overall scores, although the overall score is not displayed on the Quantification Tool worksheet. Each functional category is weighted by 0.20; in other words, each category accounts for 20% of the overall reach score. Because category scores are additive, a maximum overall score of 1.00 is only possible when parameters within all five categories are evaluated. For example, if only Hydrology, Hydraulics, and Geomorphology parameters are evaluated, the maximum overall score will be 0.60.<sup>2</sup>

**Calculating Functional Feet** – Change at an impact or mitigation site is the difference between the existing (pre-project) and proposed (post-project) scores. Existing condition scores (ECS) and proposed condition scores (PCS) are multiplied by existing and proposed stream length, respectively, to calculate the change in functional feet ( $\Delta FF$ ).

The Quantification Tool worksheet calculates change in functional feet (FF) as follows:

$$\text{Existing FF} = \text{ECS} * \text{Existing Stream Length}$$

$$\text{Proposed FF} = \text{PCS} * \text{Proposed Stream Length}$$

$$\text{Change in FF } (\Delta FF) = \text{Proposed FF} - \text{Existing FF}$$

**Functional lift** is generated when the proposed function feet value is greater than the existing functional feet value and the third equation above yields a positive value. A negative value would represent a **functional loss**.

$\Delta FF$  values are displayed in the Quantification Tool worksheet Functional Change Summary table. In the Debit Calculator workbook, this information is displayed on the Debit Calculator worksheet (Section 1.2.8).

Overall reach scores are additive across functional categories and thus do not total 1.00 unless all functional categories are evaluated. If the overall score only considers hydrology, hydraulics, and geomorphology, the maximum possible overall score would be 0.60, and would not reflect the functional capacity definitions used in Table 1. In the SQT workbook, the overall scores for the reach are calculated in the Functional Change Summary table.

<sup>2</sup> Note that the Debit Calculator assumes default scores for the physicochemical and biology functional categories in the Existing Condition worksheet.

Functional Category	Function-Based Parameters	Parameter	Category	Category
Hydrology	Catchment Hydrology	0.62	0.49	Functioning At Risk
	Reach Runoff	0.35		
Hydraulics	Floodplain Connectivity	0.34	0.17	Not Functioning
	Flow Dynamics	0.00		
Geomorphology	Large Woody Debris (LWD)	0.24	0.09	Not Functioning
	Lateral Migration			
	Bed Material Characterization	0.00		
	Bed Form Diversity	0.00		
	Riparian Vegetation	0.12		
Physicochemical	Temperature	0.53	0.66	Functioning At Risk
	Turbidity	0.79		
	Diatoms			
Biology	Macroinvertebrates	0.33	0.17	Not Functioning
	Fish	0.00		

**Figure 7: Scoring Example**

**Color-Coded Scoring** – When index values are populated in the Quantification Tool worksheet, cells will automatically change color to identify where on the reference curve the field value lies (Figure 7). Green coloring indicates field values and index scores that represent a functioning (reference standard) range of condition; yellow indicates field values and index scores that represent a functioning-at-risk range of condition; and red indicates field values and index scores that represent a not-functioning range of condition (see Table 1 for definitions). This color-coding is provided as a communication tool to illustrate the relative condition of the various metrics and parameters assessed. This is particularly useful when comparing existing to proposed condition, as well as reviewing the summary tables and monitoring data included in the SQT workbook (both are described below).



### ***Functional Lift and Loss Summary Tables***

The Quantification Tool worksheet of the SQT workbook summarizes the scoring at the top of the worksheet, next to and under the Site Information and Reference Selection section. There are four summary tables: Functional Change Summary, Mitigation Summary, Functional Category Report Card, and Function-Based Parameters Summary.

Functional Change Summary – This summary (Figure 8) provides the change in overall condition based on information entered in the Existing Condition Assessment and Proposed Condition Assessment sections and incorporates the length of the project to calculate the existing and proposed FF and  $\Delta FF$ .

The change in overall condition is the difference between the reach ECS and PCS. The summary includes the existing and proposed stream lengths to calculate and communicate FF. Since the condition score is 1.00 or less, the FF of a stream reach are always less than or equal to the actual stream length.

The  $\Delta FF$  is the amount of functional lift or loss resulting from the project. The flow type (P – **perennial**, I – **intermittent**, or E – **ephemeral**; see glossary) and the Strahler stream order (Strahler 1957) provide context for the  $\Delta FF$  value generated. Yield is also calculated in this table as  $\Delta FF$  divided by the proposed length of the project reach.

<b>FUNCTIONAL CHANGE SUMMARY</b>	
Existing Condition Score (ECS)	0.46
Proposed Condition Score (PCS)	0.76
PCS - ECS	0.30
Existing Stream Length (ft)	1000
Proposed Stream Length (ft)	1200
Change in Stream Length (ft)	200
Existing Functional Feet (FF)	460
Proposed Functional Feet (FF)	912
Proposed FF - Existing FF ( $\Delta FF$ )	452 P2
FF Yield (FF/ft)	0.38

***Figure 8: Example Functional Change Summary Table for a Second Order Perennial (P2) Stream***

Mitigation Summary – This summary table (Figure 9) reports the change in functional feet ( $\Delta FF$ ) that results from the reach-scale restoration activities. If this value is a positive number, then functional lift is occurring at the project site. A negative number represents a functional loss. The flow permanence (P – perennial, I – intermittent, or E – ephemeral) and the Strahler stream order (Strahler 1957) provide context for the  $\Delta FF$  value generated.

MITIGATION SUMMARY		
452 P2	(FF)	Lift

*Figure 9: Example Mitigation Summary Table for a Second Order Perennial (P2) Stream*

For projects that include multiple reaches, the results from the Mitigation Summary for each reach can be summed to calculate the total change in functional feet for an entire project.

In the Debit Calculator workbook the functional feet are summarized in the Functional Loss Summary table. This table shows the flow permanence and stream order for each stream reach and totals the change in functional feet for all ten reaches included in the Debit Calculator workbook.

Functional Category Report Card – In the SQT workbook, this summary presents a side-by-side comparison of the functional category scores based on the ECS and PCS from the Condition Assessment sections of the worksheet (Figure 10). This table provides a general overview of the functional changes pre- and post-project to illustrate where the change in condition and  $\Delta FF$  are anticipated.

FUNCTIONAL CATEGORY REPORT CARD			
Functional Category	ECS	PCS	Functional Change
Hydrology	0.49	0.69	0.20
Hydraulics	0.66	0.99	0.33
Geomorphology	0.33	0.82	0.49
Physicochemical	0.64	0.73	0.09
Biology	0.17	0.57	0.40

*Figure 10: Example Functional Category Report Card*

Function Based Parameters Summary – In the SQT workbook, this summary provides a side-by-side comparison for individual parameter scores (Figure 11). Values are pulled from the Condition Assessment sections of the worksheet. This table can be used to better understand how the category scores are determined and serves as a quality control check to see if a parameter was assessed for both the existing and proposed condition assessments. For example, the parameter summary table in Figure 11 illustrates that more than just the required parameters were assessed and that all parameters were assessed in both the existing and proposed condition assessments.

FUNCTION BASED PARAMETERS SUMMARY			
Functional Category	Function-Based Parameters	Existing Parameter	Proposed Parameter
Hydrology	Catchment Hydrology	0.62	0.62
	Reach Runoff	0.35	0.75
Hydraulics	Floodplain Connectivity	0.69	0.98
	Flow Dynamics	0.63	1.00
Geomorphology	Large Woody Debris	0.71	0.78
	Lateral Migration	0.10	1.00
	Bed Material Characterization	0.47	0.61
	Bed Form Diversity	0.33	0.92
	Riparian Vegetation	0.06	0.78
Physicochemical	Temperature	0.53	0.63
	Turbidity	0.74	0.82
	Diatoms		
Biology	Macroinvertebrates	0.33	0.35
	Fish	0.00	0.78

*Figure 11: Example Function-based Parameters Summary Table*

### 1.2.5 Monitoring Data Worksheet

This worksheet is included in the SQT workbook, but not the Debit Calculator workbook. The Monitoring Data worksheet contains 11 condition assessment tables identical to the Existing and Proposed Condition Assessment sections in the Quantification Tool worksheet. The first table on the Monitoring Data worksheet is identified as the As-Built condition followed by 10 condition assessment tables for monitoring. The user can enter the monitoring date and year at the top of each condition assessment table, e.g., 1 for the first field season post-project. The methods for calculating index values and scoring are identical to the Quantification Tool worksheet (Section 1.2.4).

In order to calculate functional change, the same metrics must be used in each condition assessment. In other words, if a value is entered for a metric in the Existing and Proposed Condition Assessment, a field value must also be entered for the As-Built Condition and for monitoring events in the Monitoring Data worksheet. Monitoring events should occur within the index periods specified for each selected metric, and wherever possible, data collection should occur at a similar time of year for each monitoring event. Additional monitoring schedule considerations for mitigation projects are described in Section 3.4.

### 1.2.6 Data Summary Worksheet

This worksheet is included in the SQT workbook, but not the Debit Calculator workbook. This worksheet provides a summary of project data from the existing condition, proposed condition, As-Built condition, and monitoring assessments, as pulled from the Quantification Tool and

Monitoring Data worksheets. The Data Summary worksheet features a Function Based Parameter Summary table, a Functional Category Report Card, and four plots showing this information graphically. *This worksheet is included for information purposes and does not require any data entry.*

### 1.2.7 Reference Curves Worksheet

The Reference Curves worksheet contains the reference curves used to convert metric field values into index values in the Quantification Tool, Monitoring Data, Existing Conditions, and Proposed Conditions worksheets. This worksheet is present in both the SQT and Debit Calculator workbooks, although it is hidden in the Debit Calculator workbook.

*This worksheet is included for information purposes and does not require any data entry. This worksheet is locked to protect the calculations used to convert field values to index values.*

The numeric index value range (0.00 to 1.00) was standardized across metrics using the definitions of functional capacity, i.e., functioning, functioning-at-risk and not-functioning conditions provided in Table 1 (Section 1.2). Reference curves are tied to specific benchmarks (thresholds) that represent the degree to which the reach condition departs from a reference standard.

In this worksheet, reference curves are organized into columns based on functional category and appear in the order they are listed on the Quantification Tool worksheet. One metric can have multiple curves depending on how the reference curves were stratified. For example, the large woody debris frequency metric is stratified by ecoregion. All reference curves and their stratification are described in the Scientific Support for the AKSQTint (Steering Committee 2021).

There may be instances where better data to inform reference standard and index values are available for a project. Submit your request to use other data as an alternative to the Corps. The Corps can approve an exception to using the existing reference curves and index values for a metric within the AKSQTint where sufficient data are available to identify reference standards.

Field data supporting refinement of reference curves and evaluation of metrics are appreciated. Written proposals should include a justification and rationale (e.g., data sources and/or literature references) and should follow the framework for identifying reference curves, threshold values, and index scores. Feedback may be submitted at any time to the USACE at [regpagemaster@usace.army.mil](mailto:regpagemaster@usace.army.mil) with subject line of 'SQT Request'.

### 1.2.8 Debit Calculator Worksheet

This worksheet is only present in the Debit Calculator workbook, and not in the SQT workbook. The Debit Calculator worksheet is where users enter data describing the impacts to each reach by selecting an **impact severity tier**, and where functional loss is calculated. The worksheet consists of project information, the Functional Loss Summary table, a summary of the results from the Existing and Proposed Conditions worksheets within the Debit Calculator workbook, and reference information for filling out the Functional Loss Summary table. Cells that allow

input are shaded grey and most other cells are locked. Each section of the Debit Calculator worksheet is discussed below.

### ***Components of the Debit Calculator Worksheet***

**Project Information** – Provide the name of the project, date of the submittal, and any permit or application number assigned. This information will automatically populate from the Project Assessment worksheet.

The user enters the stream length, debit option, and impact severity tier in the Functional Loss Summary table (Figure 12). This information is used to quantify the resource value function loss for each reach.

<b>FUNCTIONAL LOSS SUMMARY</b>								
<b>Stream ID by Reach</b>	<b>Debit Option</b>	<b>Existing Reach Length</b>	<b>Proposed Reach Length</b>	<b>Impact Severity Tier</b>	<b>Existing Condition Score (ECS)</b>	<b>Proposed Condition Score (PCS)</b>	<b>Change in Functional Feet (ΔFF)</b>	<b>Flow Type and Stream Order</b>
R1	3	1000	800	Tier 5	1.00	0.00	-1000.0	P4+
R2	2	1000	800	Tier 5	0.88	0.00	-880.0	P4+
R3	1	1000	1000		0.39	0.29	-100.0	P4+
0								
0								
0								
0								
0								
0								
0								
<b>Total Functional Loss (Debits in FF):</b>							<b>-1980.0</b>	

***Figure 12: Debit Tool Example***

**Stream ID by Reach** – Applicants enter each impact site by reach. This information auto-populates from the Project Assessment worksheet. The user can score up to 10 reaches within each Debit Calculator workbook. If the project contains more than 10 reaches, more than one Debit Calculator workbook will need to be used.

**Debit Option** – There are three options for calculating functional loss at an impact site. Users should select Option 1, 2, or 3 from the drop-down menu. These options are described below and summarized in Table 2.

*Table 2: Summary of Debit Options*

Debit Option	Existing Condition Score (ECS)	Proposed Condition Score (PCS)
1	Assess existing condition using Existing Condition worksheet.*	Estimate proposed condition using Proposed Condition worksheet.
2	Assess existing condition using Existing Condition worksheet.*	Estimate proposed condition based on impact severity tier.
3	Use standard/default ECS.	Estimate proposed condition based on impact severity tier.
* Users can decide whether to measure physicochemical and biology functions or accept the default score for these functional categories.		

- Option 1 calculates functional loss using data entered in the Existing Condition and Proposed Condition worksheets (described in Section 1.2.4). For this option, the user must conduct an existing condition assessment within the project reach and be able to accurately **predict the functional loss for all five functional categories** using project design reports, drawings, or field investigations.
  - Physicochemical and biology functions should be assessed for the existing condition, or the default condition score will be assumed for these functional categories. The default ECS for these functional categories is 1.00. Field values for physicochemical and biology metrics are required on the Proposed Condition worksheet that represent reasonable estimates of loss associated with the proposed impact activity.
- Option 2 calculates functional loss using a combination of existing condition assessment data from the Existing Condition worksheet (Section 1.2.4) and the formulas in the Debit Calculator worksheet to calculate functional loss. For this option, the user must conduct an existing condition assessment of the project reach in the same way as Option 1.
- Option 3 calculates functional loss using only the Debit Calculator worksheet. **This option is the fastest and easiest** method for determining functional loss; users do not need to conduct an existing condition assessment. For this option, the Debit Calculator worksheet relies on a default ECS for the reach and the formulas in the Debit Calculator worksheet to calculate functional loss. The default ECS is 1.00.

A minimum ECS score of 0.30 is applied when calculating debits using Debit Options 1 and 2, where the existing condition is assessed. This minimum score protects aquatic resource functions, particularly those that may not be quantified by the SQT.

Note that the debit calculator is strictly for calculating functional loss; the PCS cannot exceed the ECS. The Debit Calculator worksheet will only yield negative changes in functional feet.

Existing Stream Length – Calculate the length of the stream that will be directly impacted by the permitted activity. Stream length should be measured along the centerline of the channel.

Proposed Stream Length – Calculate the length of stream channel anticipated from the proposed impact. For artificial water conveyances, the proposed length is the length of the

conveyance. If the stream will be straightened by the permitted activity, the proposed stream length will be less than the existing stream length. Proposed stream lengths should not exceed the existing stream length; the debit calculator will highlight the cell if the proposed stream length is longer than the existing stream length.

**Impact Severity Tier** – Determination of an impact severity tier is needed to calculate a PCS using Debit Options 2 and 3. The Impact Severity Tier (0-5) is selected from a drop-down menu. The impact severity tier is a categorical determination of the amount of adverse impact to stream functions, ranging from no loss to total loss from a proposed activity. Table 3 lists the impact severity tiers along with a description of impacts to key function-based parameters and example activities that may lead to those impacts. Note that some activities could be in multiple tiers depending on the magnitude of the impact and efforts taken to minimize impacts using bio-engineering techniques or other low-impact practices. Table 4 provides example activities for each tier and detailed descriptions used to inform estimates of functional loss are provided in Appendix C.

**Table 3: Impact Severity Tiers**

Tier	Description (Impacts to function-based parameters)
0	No permanent impact on any of the key function-based parameters: flow dynamics, floodplain connectivity, lateral migration, bed form diversity, and riparian vegetation.
1	Minor impacts, primarily to riparian vegetation and/or lateral migration.
2	Minor impacts to floodplain connectivity OR minor to moderate impacts to bed form diversity and flow dynamics. Typically accompanied by moderate to severe impacts to riparian vegetation and lateral migration. Minor impacts to some physicochemical and biology functions possible.
3	Moderate impacts to floodplain connectivity. Typically accompanied by moderate to severe impacts to riparian vegetation, lateral migration, bed form diversity, and flow dynamics. Minor to moderate impacts to some physicochemical and biology functions.
4	Moderate to severe impacts to most hydraulic and geomorphic functions. Moderate to severe impacts to physicochemical and biology functions.
5	Loss of all aquatic functions.



**Table 4: Example Impact Activities.***Refer to Appendix C for detailed descriptions of these activities and more example activities.*

Example Activity	Potential Impact Severity Tier
Bioengineered bank stabilization	Tier 0
Bioengineered bank stabilization with riprap toe protection	Tier 2, 3, or 4
Bank stabilization/armoring with riprap	Tiers 2, 3, or 4
Full span bridge	Tiers 2 or 3
Stream simulation culverts	Tiers 3 or 4
Embedded hydraulic design culverts	Tier 4
Culverts substantially altering channel characteristics	Tier 5
Stream channelization	Tier 5

The Functional Loss Summary table summarizes all the necessary information for each impact reach (Figure 12). Once the requisite information has been provided, the Functional Loss Summary table will automatically calculate the PCS. Once the PCS is calculated, the existing and proposed stream lengths are used to calculate the  $\Delta FF$  using the equation described in Chapter 1.2.4. The Debit Calculator can only calculate loss and therefore, the change in functional feet can only be less than or equal to 0. The Functional Loss Summary table (Figure 12) also automatically identifies the flow type and stream order from the information entered in the Project Assessment worksheet to provide context to the change in functional feet value. Up to 10 stream impacts can be reported within a single workbook. The worksheet will automatically total the  $\Delta FF$  when data is entered for all project reaches.

The following sections describe the support information on the Debit Calculator worksheet. Tables 2 and 3 are provided on this worksheet for reference in selected debit options and impact severity tiers.

**ECS and PCS Summary Table** – The overall ECSs and overall PCSs of all stream reaches from the Existing Conditions and Proposed Conditions worksheets are summarized in a table located below the Functional Loss Summary Table. These values are used to auto-populate the Functional Loss Summary Table when Debit Options 1 or 2 are selected.

**Impact Severity Tiers and Percent Functional Loss** – The Debit Calculator worksheet calculates the PCS differently depending on which impact severity tier is selected (Table 5). These factors were based on projected functional loss and grouped by common impact activities with similar functional loss (refer to Appendix C).

**Table 5: Impact Severity Tiers and PCS Calculation, where ECS is the existing condition score and PCS is the proposed condition score**

Impact Severity Tier	PCS Equation	Percent Loss (%)
1	$PCS = 0.9 * ECS$	10
2	$PCS = 0.7 * ECS$	30
3	$PCS = 0.4 * ECS$	60
4	$PCS = 0.2 * ECS$	80
5	$PCS = 0$	100

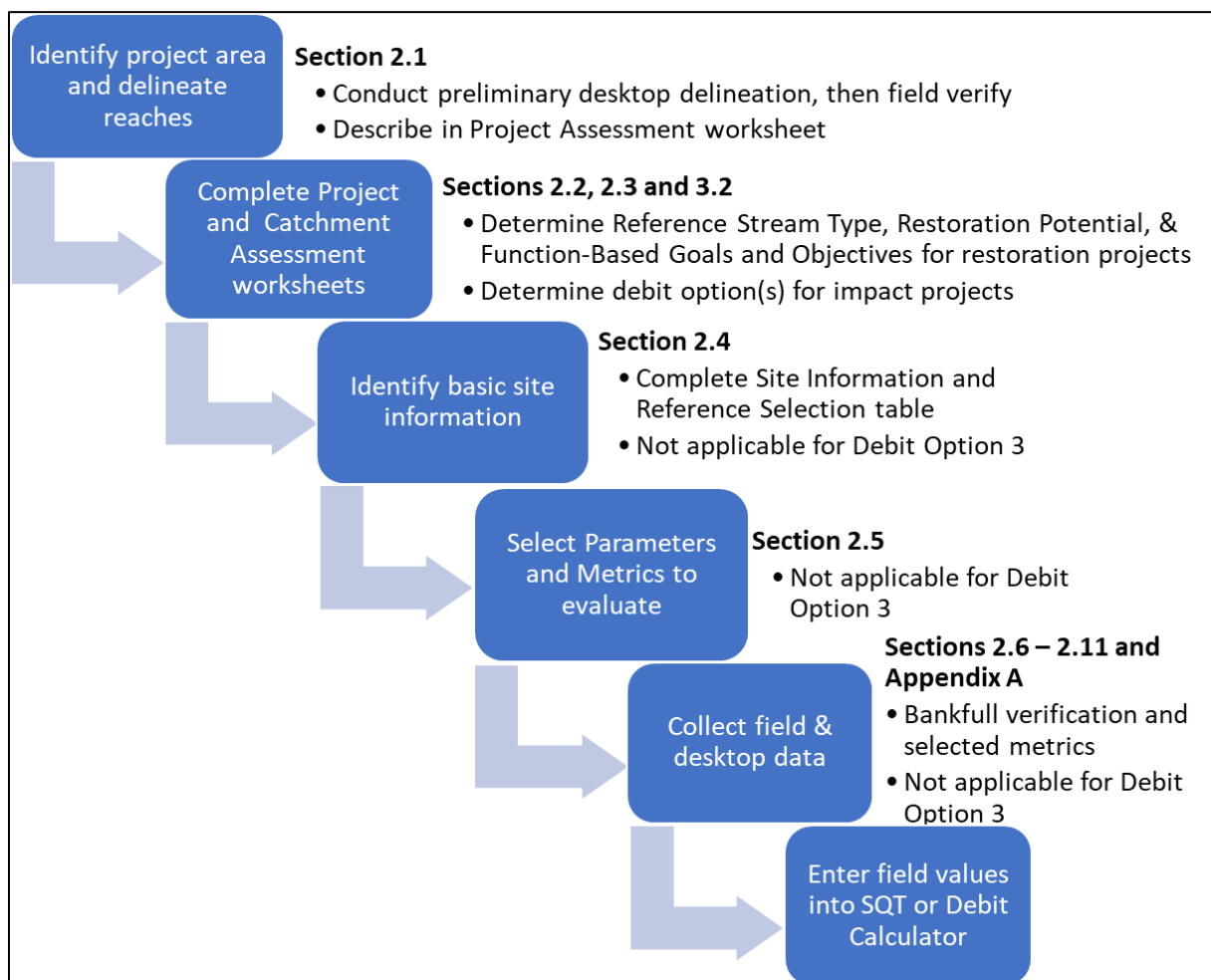
## Chapter 2. Data Collection and Analysis

This chapter provides instruction on how to collect, analyze, and input data used in the SQT and Debit Calculator workbooks. Figure 13 provides a flow chart of the typical process for completing the SQT workbook.

Teams collecting and analyzing these data should have experience and expertise in botany, aquatic ecology, hydrology, and geomorphology as well as experience and expertise applying the assessment methods used to calculate the metrics included in the AKSQTint.

**Interdisciplinary teams of at least two people with a combination of these skill sets are necessary to ensure consistent and accurate data collection and analyses.** Field trainings in the methods outlined herein, as well as the Stream Functions Pyramid Framework, are recommended to ensure that the methods are executed correctly and consistently.

Each method in this chapter will describe the requisite experience for individuals applying the methods.



*Figure 13: AKSQTint Process Flow Chart*

This chapter includes methods for metrics that can be evaluated in the office, steps for calculating metrics, as well as a summary of field methods. Multiple metrics require data from cross-section and longitudinal profile surveys. This manual does not go into survey techniques, refer to Harrelson et al. (1994). **Longitudinal profiles require survey of the thalweg, water surface elevation, bankfull, and low bank features.**

A rapid survey option for field data collection is available for metrics derived from longitudinal profile and cross-section survey data and is described in Appendix A.

Few metrics are unique to the AKSQTint, and data collection procedures are often consistent with other instruction manuals or literature. One such reference is BLM Technical Reference 1735-2, *AIM National Aquatic Monitoring Framework: Field Protocol for Wadeable Lotic Systems* (BLM 2017). Multiple metrics in the AKSQTint are derived using the data collection methods outlined in that document. **Where appropriate, this chapter and Appendix A will reference the original methodology** to provide technical explanations and make clear any differences in data collection or calculation methods needed for the AKSQTint.

## 2.1 Reach Delineation and Representative Sub-Reach Selection

The AKSQTint is a reach-based assessment methodology, and each reach is evaluated separately. A large project may be subdivided into multiple reaches (each requiring its own workbook), as stream condition or character can vary widely from the upstream end of a project to the downstream end. In addition to metrics that assess in-channel conditions for each project reach, required metrics also assess the floodplain width, riparian area, and runoff from adjacent land (Figure 14).



*Figure 14: The AKSQTint assessment includes measures within the stream channel, riparian area, floodplain, and the catchment.*

Delineating stream reaches within a project area occurs in two steps. The first step is to identify whether there is a need to separate the project area into multiple reaches based on variations in stream physical characteristics and/or differences in project designs or magnitude of impacts. Once project reaches are determined, the user selects a **representative sub-reach** within each project reach to quantitatively assess metrics. The processes to define project reaches and representative sub-reaches are described in detail below in Sections 2.1.1 and 2.1.2 respectively.

### **2.1.1 Delineation of Project Reach(es)**

The user should determine whether their project area encompasses a single homogeneous reach, or multiple potential reaches. For this purpose, **a reach is defined as a stream segment with similar processes and morphology, including characteristics such as stream type (Rosgen 1996), stability condition, riparian vegetation type, and bed material composition.** Reaches within a project site may vary in length depending on the variability of the physical stream characteristics within the project area (Example 3).

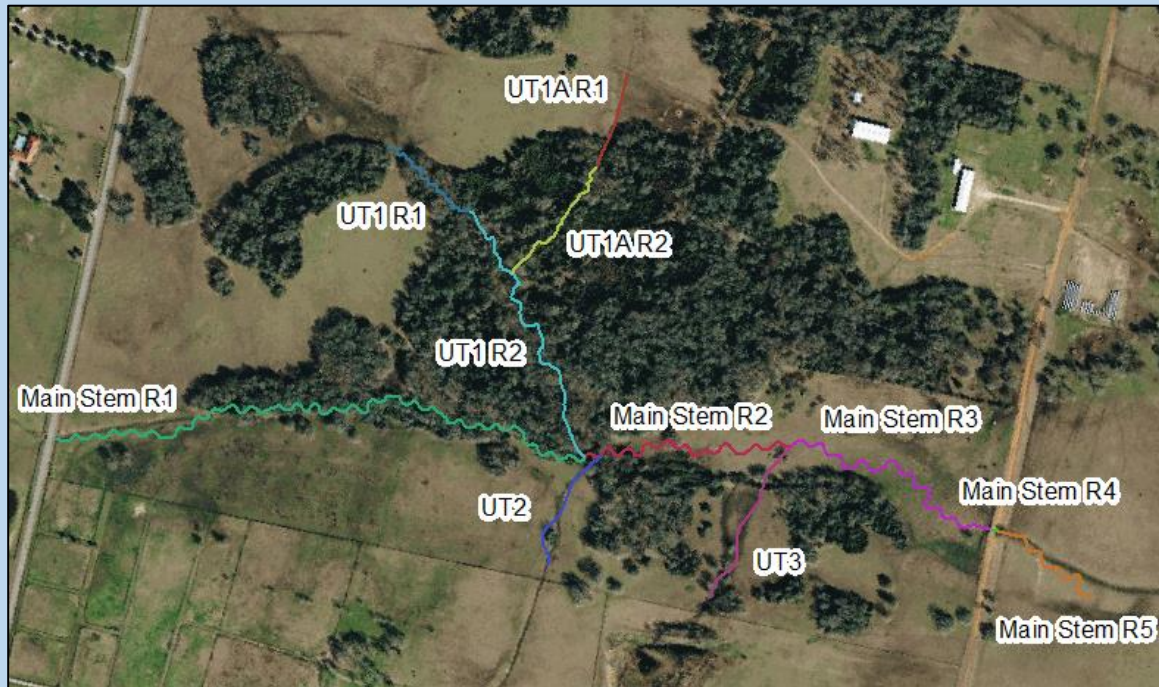


Users can review aerial imagery, the National Hydrography Dataset (NHD), and other desktop tools to preliminarily determine reach breaks; these determinations should be verified in the field. Users should provide justification for the final reach breaks in the Reach Description section of the Project Assessment worksheet. Specific guidance is provided below to assist in making consistent reach identifications:

- Separate streams, e.g., tributaries vs. main stem, are considered separate project reaches.
- A tributary confluence should lead to a reach break. Where a tributary enters the main stem, the main stem should be split into two project reaches - one upstream and one downstream of the confluence. The contribution of small tributaries, as compared to the drainage area of the main stem channel, may not require a reach break.
- Reach breaks should occur where there are changes to process drivers, valley morphology, stream type (Rosgen 1996), or bed material composition.
- Reach breaks should occur where there are distinct changes in the level of anthropogenic modifications, such as narrowed riparian width from road embankments, concrete lined channels, dams, stabilization, or culverts/pipes. For example, a culvert's footprint would be evaluated as a separate project reach from the reaches immediately up and downstream of the culvert.
- Multiple project reaches are needed where there are differences in the proposed magnitude of impact or mitigation approach (e.g., enhancement vs. restoration) within the project area. For example, restoration approaches that reconnect stream channels to their original floodplain would be evaluated in a separate reach from portions of a project that only include bank stabilization activities.

**Example 3: Project Reach Delineation**

The following is an example showing how project reaches are identified based on physical observations. The project area includes five streams. The main stem channel was delineated into five reaches, two unnamed tributaries (UT) were delineated into two reaches each, and the remaining two UTs as individual project reaches. This project has a total of 11 project reaches and an Excel Workbook would need to be completed for each.

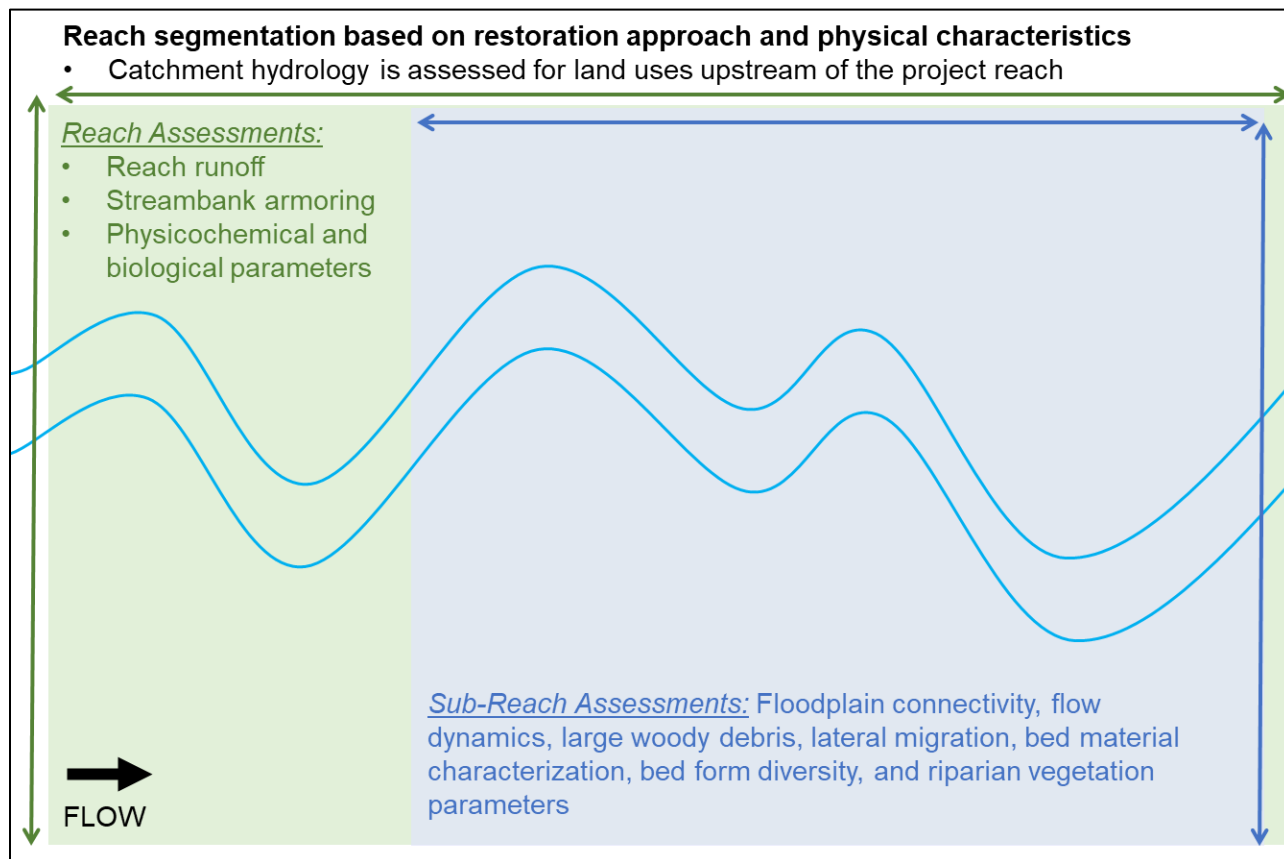


Reach	Reach Break Description
Main Stem R1	Beginning of project to UT1 confluence where drainage area increases by 25%.
Main Stem R2	To UT3 confluence where there is a change in slope.
Main Stem R3	To culvert. Bed material is finer and bed form diversity is impaired below culvert.
Main Stem R4	40 feet through the culvert.
Main Stem R5	From culvert to end of project.
UT1 R1	Property boundary to the last of a series of headcuts caused by diffuse drainage off the surrounding agricultural fields.
UT1 R2	To confluence with the main stem. Restoration approach differs between UT1 R1 where restoration is proposed to address headcuts and this reach where enhancement is proposed.
UT1A R1	Property boundary to edge of riparian vegetation. Reach is more impaired than UT1A R2, restoration is proposed.
UT1A R2	To confluence with UT1. Enhancement is proposed to preserve riparian buffer.
UT2 & UT3	Beginning of project to confluences with Main Stem. Reaches are actively downcutting and supplying sediment to the main stem.



### 2.1.2 Representative Sub-Reach Determination

Some metrics will be evaluated along the entire project reach length, some will be evaluated at a specific point within the project reach and other metrics will be evaluated in a representative sub-reach (Figure 15). Selecting a representative sub-reach is necessary to avoid having to quantitatively assess very long stream lengths with similar physical conditions. The representative sub-reach should be at least 20 times the **bankfull** width or two meander wavelengths (Leopold 1994), whichever is longer. If the entire reach is shorter than 20 times the bankfull width, then the entire project reach should be assessed. Assessment length and sampling locations are described below for each metric and parameter.



**Figure 15: Reach and Sub-Reach Segmentation**

#### Hydrology Functional Category:

- Catchment hydrology metrics are evaluated for the portion of the catchment that drains to the upstream extent of the project reach.
- Reach runoff metrics are evaluated within the portion of the catchment draining between the upstream and downstream extents of the project reach and within the entire project reach.

### Hydraulics Functional Category

- Floodplain connectivity is assessed within the representative sub-reach and includes assessments within the channel and on the floodplain.
- Flow dynamics are assessed within the channel of the representative sub-reach.

### Geomorphology Functional Category:

- Large woody debris (LWD), lateral migration (except the armoring metric), bed form diversity, and riparian vegetation are all assessed within the representative sub-reach. Riparian vegetation is assessed within the floodplain. The others are assessed within the channel.
- Percent streambank armoring is assessed along the entire project reach.

### Physicochemical and Biology Functional Categories:

- Sampling should occur within the project reach, but specific locations will vary by metric.

## 2.2 Reference Stream Type

Reference stream type represents the stream type that should occur in a specific landscape setting given current hydrogeomorphic watershed- and reach-scale processes. To determine reference stream type, users should have experience with and knowledge about channel evolution and the Rosgen Stream Classification system. The AKSQTint relies on the Rosgen stream type classifications (Rosgen 1996) to determine reference stream type. **The AKSQTint does not require Natural Channel Design restoration approaches.** Reference stream type is used in the AKSQTint to stratify reference curves for the entrenchment ratio (ER), pool spacing ratio, and pool depth ratio metrics. Stream type classifications and basic fluvial landscapes in which the different stream types typically occur are described in detail in *Part 654 Stream Restoration Design National Engineering Handbook* (NRCS 2007).

When using the Debit Calculator workbook, reference stream type is entered in the Existing Condition worksheet and users should select reference stream type after considering the existing stream type and channel succession. The Rosgen Channel Succession Scenarios (Rosgen 2006) or other stream evolution models (Cluer and Thorne 2014) can be used as a guide for determining the reference stream type.

When using the SQT workbook, reference stream type is entered in the Project Assessment worksheets and is the restoration target **at project closeout**. Historic, geomorphic, and stratigraphic evidence can be used in addition to the tools noted above to determine reference stream type. Information from a reference reach (Section 2.5.1) and the design process (e.g., fluvial landscape, historic channel conditions, watershed hydrology, sediment transport, and/or anthropogenic constraints) can also be used to inform reference stream type (Example 4). Once the reference stream type has been selected, the evolution (past, present, and future) should be further explained (refer to restoration potential process in Chapter 3). This explanation provides further support for selection of reference stream type.

This version of the AKSQTint was developed with a focus on single-thread channels and is not applicable to multi-thread channels. The Rosgen stream classification system describes six single-thread channels, and two multi-thread stream types: D and D<sub>A</sub> streams.

- In general, for a reach to be considered multi-thread it must have at least 3 primary flow paths that are active at baseflow for most of the reach length.
- D streams are braided systems with low biotic interaction, high stream power, and low erosion resistance, resulting in active bank migration that adjusts primarily through lateral extension and aggradation (Rosgen 1996; Castro and Thorne 2019). These systems are response reaches (Castro and Thorne 2019), often occurring downstream of a high sediment supply, where the system will adjust with every high flow event. In Alaska, examples include alluvial fans and glacial outwash valleys.
- D<sub>A</sub> streams are anastomosed systems (Rosgen 1996), typically in low gradient valleys with high biotic interaction (likely an obligate vegetation community, beaver dam complexes, beaver meadows, or large wood), low stream power, and moderate erosion resistance (Castro and Thorne 2019). These systems are also response reaches but they are much less dynamic than braided systems because they have less sediment supply and less stream power. They function as stream-wetland complexes.

#### *Example 4: Reference Stream Type*

Pre-restoration (existing) stream type: Gc

Historic aerial imagery depicts that the stream was channelized prior to 1950. Historical accounts verify that beavers were present in the area and the historic condition may have been a beaver meadow. There is no evidence of beaver today.

A Gc stream type in a low gradient, **unconfined alluvial valley** will often evolve into an F and then a C stream type (Rosgen Channel Succession Scenarios; Rosgen 2006). If the reach is in a wide alluvial valley, the reference stream type would likely be a C or E.

However, it may sometimes evolve into a Bc stream type if the erosion resistance is greater than the driving forces of stream power and sediment discharge or if the stream is located within a steep and narrow valley (e.g., where urban land uses confine the natural valley).

## 2.3 Catchment Assessment

The primary purpose of the Catchment Assessment is to assist in determining restoration potential for restoration and mitigation projects (described in Section 3.2). It is a decision-support tool rather than a quantitative scoring tool. Therefore, results from the Catchment Assessment are not scored in the SQT workbook but are used to help inform the restoration potential decision. This worksheet is also included in the Debit Tool workbook to provide an overall condition determination (good, fair, or poor) of the catchment which gives context for the hydrologic, physicochemical, and biological existing conditions.

The Catchment Assessment worksheet:

- Includes descriptions of processes and stressors that exist outside of the project reach and may affect existing condition and/or limit functional lift.
- Does not pertain to stressors occurring within the project area that can be addressed as part of project activities.
- Evaluates conditions primarily upstream, but sometimes downstream of the project reach.

Instructions for collecting data and describing each process and stressor are provided in this section.

There are 13 defined categories, with space for an additional user-defined category. There are three choices to rate the catchment condition for each category: good, fair, and poor. The Catchment Assessment relies on data available from various online or local sources and site-specific data obtained through site walks within and near the project area. Data needed to assess each category are described below. Descriptions of good, fair, and poor are provided in the Catchment Assessment worksheet for each category; data used to evaluate each selection should be documented.

Once all categories of the Catchment Assessment are completed, the user should provide an overall watershed condition based on best professional judgement (in both the SQT and Debit Tool workbooks), and determine the restoration potential for the reach (only in the SQT workbook; refer to Section 3.2).

### **1. Riparian Buffer Vegetation**

This category considers the extent and connectivity of riparian areas upstream of the project area. Riparian areas serve as wildlife habitat corridors, sources of large woody debris, protect and buffer the stream channel from external disturbance (e.g., noise, windthrow, excessive lateral migration, and erosive runoff velocities), and provide nutrient and pollutant removal benefits.

Catchment assessment ratings: Catchments in good condition will have natural riparian plant communities that occupy more than 2/3 of the valley bottom, and riparian corridors that are largely (e.g., at least 90%) contiguous along the contributing catchment stream length. Catchments in fair condition will have natural riparian plant communities that occupy at least 1/3 of the valley bottom and riparian corridors that are somewhat contiguous (e.g., do not exceed 30%) along the contributing catchment stream length. Catchments in poor condition do not meet the above criteria and will either have narrow riparian corridors or gaps in the riparian corridor that exceed 30% of the contributing catchment stream length.

Data collection: The prevalence of riparian vegetation on streams draining to the project reach can be determined using recent aerial imagery<sup>3</sup> or by field observations within the catchment.

### **2. Sediment Supply**

The sediment supply entering a project reach plays an important role in determining restoration potential and reference stream type. Sediment transport regimes are generally described as

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<sup>3</sup> Google Earth or high-resolution digital imagery is available from DigitalGlobe. DigitalGlobe imagery is available for purchase but is free for federal employees.

source, transport, or response and characterize the relationship between supply and transport capacity (Montgomery and Buffington 1998).

This category characterizes the anthropogenic alterations to sediment supply through excessive supply. Unnaturally high sediment loads from upstream bank erosion, upland erosion, roadways, land management practices, or from the movement of sediment stored in the bed may change a transport system into a response system and create a challenging design problem. Unnatural sources of sediment within the riparian area of the upstream contributing stream length can be resuspended and transported by overbank flows or channel migration. Such sediment sources could include placer tailings, gravel stockpiles, and fines from settling ponds. Additional evidence of altered sediment supply could be extensive channel alteration of the contributing reach length (e.g., channel straightening and armoring).

For transport systems, a project reach could aggrade if the design does not adequately address alterations in the sediment load. Note that this category addresses human-altered sediment regimes; systems with naturally high sediment supplies would not score poorly unless the natural sediment transport processes were altered.

Catchment assessment ratings: If there are multiple lines of evidence indicating the sediment supply is moderately or substantially altered from the natural condition, then the catchment condition would be considered fair or poor, respectively. The distinction between fair and poor is based on the proximity of excess sediment sources to the project reach or qualitative evaluation of the sediment load based on observations of conditions in the reach and upstream.

If there are only a few sources of sediment or sediment sources are naturally occurring upstream of the project reach, then the catchment condition is good.

Data collection: Users should review recent aerial imagery<sup>4</sup> of the catchment and walk as much of the upstream channel as possible looking for evidence of altered sediment loads, including extensive bank erosion, mid-channel bars, lateral bars, sediment fans at mouths of tributaries, and other evidence of excess human sources of sediment (Example 5).

***Example 5: Indicators of Human-Altered Sediment Regimes***

For the transport system pictured below, the alternating point bars lacking vegetation indicate sediment storage in the channel that can be mobilized during high flows.



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<sup>4</sup> Google Earth or high-resolution digital imagery is available from DigitalGlobe. DigitalGlobe imagery is available for purchase but is free for federal employees.



There are many tools available to estimate the sediment load from surrounding land use, including the: Spreadsheet Tool for Estimating Pollutant Loads (STEPL v4.1; Tetra Tech, Inc. 2011), Watershed Assessment of River Stability and Sediment Supply (WARSSS; Rosgen 2006), sediment transport capacity/supply ratio tool (Stroth et al. 2017), and Bedload Assessment for Gravel-bed Streams (Pitlick et al. 2009).

### **3. Alaska Impaired Water Body Status (303(d) listed stream)**

The Alaska Department of Environmental Conservation (DEC) maintains a list of impaired waterbodies (category 5 waters; the 303(d) list) as part of its biennial Integrated Report to EPA.<sup>5</sup> Category 5 waters with impaired aquatic life uses have exceeded water quality standards and require a Total Maximum Daily Load (TMDL) to determine pollutant reductions necessary to achieve standards. Once a TMDL is completed and approved by EPA, the impaired waterbody is removed from category 5 and placed in category 4 (TMDL completed but not yet restored) until additional monitoring shows water quality standards are achieved. It is therefore important to check the State's most recent Integrated Report for both category 4 and category 5 (303(d) listed) waters in the catchment.

Most stream restoration and compensatory mitigation projects do not improve a sufficient portion of the stream or catchment to overcome poor water quality. However, projects could be done in coordination with other watershed-scale efforts to address impairments, such as in a watershed where other efforts are underway to remediate mine-related water quality issues. A poor or fair catchment rating in this category would indicate that full restoration potential would be difficult or impossible unless a large portion of the catchment is being restored or the project was being pursued in coordination with other watershed restoration efforts.

Catchment assessment ratings: Category ratings are determined by whether the stream or reach is listed as impaired, which category the stream falls into and whether the impairment is actively being mitigated. A good condition stream is not listed. A fair condition stream is listed as category 4 and the impairment is actively being mitigated. A poor condition stream is listed as category 5 or 4 and the impairment is not actively being mitigated.

Data collection: Integrated reports and spatial information on category 4 and 5 waters are available online.<sup>6</sup>

### **4. Contaminants**

There are many waters with degraded biological condition that are unassessed, thus they are absent from the 303(d) list. If recent water quality data have been collected for the reach, then it can be used to inform a condition rating in this category even if the water is not listed as impaired by ADEC. 18 AAC 70.020 outlines the criteria of aquatic life use attainment for the Integrated Report documenting impaired waterbodies. Contaminants of particular concern to aquatic life that could affect existing condition and/or limit restoration potential include, but are not limited to, turbidity or total suspended solids, temperature, nutrients, acid, petroleum products, and heavy metals. Restoration potential may be limited because efforts needed to address contaminants may be outside the scope of a mitigation or restoration project, for example because sources are outside the project area.

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<sup>5</sup> <https://dec.alaska.gov/water/water-quality/integrated-report/>

<sup>6</sup> <https://dec.alaska.gov/water/water-quality/impaired-waters/>

Catchment assessment ratings: Catchments in good condition either lack a contamination source (i.e., the catchment is unaltered and natural land uses comprise much of the landscape) or water quality testing has not identified contaminants that would limit restoration efforts. Poor condition catchments have water quality results that limit the ecological functioning within the reach. In the absence of water testing, if two or more contaminant sources are identified or evidence indicates a contaminant source is toxic to aquatic life then the catchment can be considered in poor condition. A catchment is in fair condition if the water testing at the site indicates contaminants may limit aquatic life uses (it is uncertain), or testing was not conducted but 1 source of contamination within the catchment was identified.

Data collection: Users should review ADEC's database for active-status contaminated sites within the riparian area of the contributing stream length<sup>7</sup> and recent aerial imagery<sup>8</sup> for other indicators of activities in the watershed that may affect water quality. These resources and an assessment of project goals can determine whether water quality sampling and assessment is warranted.

## **5. Regulated Discharges (APDES Permits)**

Regulated discharges refer to discharges authorized under Section 402 of the CWA, via a permit issued by ADEC or EPA (e.g., within the Denali National Park and Preserve), including mechanized placer mining activities authorized by General Permit AKG370000. This does not include the discharge of dredged or fill material authorized by CWA Section 404 or by land managers. The Alaska Pollutant Discharge Elimination System (APDES) program ensures regulated discharges meet minimum water quality standards, however, standards may not exist for all relevant contaminants, or effluent limits may be technology-based rather than water quality-based (e.g., dissolved solids, conductivity, oil and grease). As such, regulated discharges occurring upstream or in proximity to the project reach may affect existing condition and/or limit full restoration potential.

Catchment assessment ratings: A catchment in good condition would have no major and few or no minor APDES facilities within one mile of the project reach. A catchment in poor condition for this category would have two or more APDES permitted facilities, at least one that is within close proximity (within 1 mile) of the project reach. A fair condition is in between, so the presence of major ADPES facilities but none within 1 mile of the project reach. APDES stormwater and temporary discharge permits should not be included when determining the rating; a change from existing to proposed condition must be attributable to project actions rather than APDES permit conditions.

Data collection: The Alaska DEC, Division of Water lists the minor and major APDES permitted facilities.<sup>9</sup>

## **6. Organism Recruitment**

Aquatic organisms rely on a variety of channel substrate sizes and characteristics to survive and reproduce. Impaired channel substrates and other factors that limit the presence of aquatic organisms surrounding the project reach can negatively impact macroinvertebrate community recruitment and the ability of fish to spawn. Recruitment and colonization of aquatic organisms

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<sup>7</sup> <https://www.arcgis.com/home/item.html?id=315240bfbaf84aa0b8272ad1cef3cad3>

<sup>8</sup> Google Earth or high-resolution digital imagery is available from DigitalGlobe. DigitalGlobe imagery is available for purchase but is free for federal employees.

<sup>9</sup> <https://dec.alaska.gov/Applications/Water/WaterPermitSearch/Search.aspx>



within stream reaches is affected by the presence of desired communities in proximity to the project site (Blakely et al. 2006; Hughes, 2007; Lake et al. 2007; Sundermann et al. 2011; Tonkin et al. 2014). Impairments to the channel, such as hardened substrates, excessive sedimentation, culverts or piping, may prevent macroinvertebrate communities from inhabiting a stream reach and extended length of channel impairments may reduce the possibility of organism recruitment.

The most common source of recolonization of benthic insects is drift from upstream. If upstream reaches or tributaries are hardened, existing and future recruitment could be affected and recolonization of restored reaches will take much longer. Emphasis needs to be given to the quality of upstream reaches for organism recruitment. This category may not fully limit future restoration potential, since benthic insects can immigrate from nearby catchments along non-water avenues (e.g., via aerial dispersion).

Catchment assessment ratings: A catchment in poor condition may have substantial channel impairments preventing desirable species from inhabiting areas immediately upstream or downstream of the project reach. In other terms, the stream is hardened within 1 mile of the project reach. A good condition is represented by adjacent channel (within 1 mile upstream and downstream) consisting of native bed and bank material. Where the channel adjacent to the project reach is not hardened but highly embedded with fine sediment and likely inhibiting organism recruitment, the catchment is in fair condition.

Data collection: This category can be assessed by walking the site and the stream reaches immediately upstream and downstream of the project reach or reviewing aerial imagery to determine if there are any impairments to organism recruitment including excessive deposition of fine sediments, concrete, piped, or hardened stretches of channel.

## **7. Barriers/ Fish Passage**

Anthropogenic barriers to aquatic organism passage refer to human structures within the channel that block the movement of fish. This can include culverts and dams without fish passage provisions. Barriers do not include beaver dams. Interference with the life history movements of resident fish should be assessed based on species presence and knowledge of habitat requirements. The user should consider whether the flow depth, velocity, or vertical jumping height across a structure or barrier may limit movement of certain species or life stages of species historically or naturally present within that catchment.

Catchment assessment ratings: A catchment in poor condition for this category has a barrier, or multiple, that create severe limitations to fish passage that adversely affect fish populations within the project reach. A fair condition may represent a catchment where minor fish passage issues are occurring during some, but not all times of the year, or barriers present nearby have been shown not to affect fish populations within the project reach. A catchment in good condition would have no anthropogenic fish barriers or any structures that would have adverse effects on fish populations in the reach.

Data Collection: Alaska Department of Game and Fish (ADF&G) maintains a statewide culvert inventory, Anadromous Waters Catalogue (AWC), and Alaska Freshwater Fish Inventory (AFFI) accessible via a web mapper that identifies crossings considered to be a passage barrier.<sup>10</sup> The statewide culvert inventory rates culverts, and those rated as red by ADF&G are fish passage

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<sup>10</sup> <https://www.adfg.alaska.gov/index.cfm?adfg=fishpassage.database>

barriers. Users should also review recent aerial imagery<sup>11</sup> of the catchment for impoundments and other structures that may limit fish passage. Site investigations and consultation with the area fishery biologist from ADF&G may yield additional information regarding the presence and severity of barriers within the catchment.

## **8. Flow Alteration**

Flow alteration typically occurs as flow regulation from impoundments, diversions, or discharges and can play a role in altering hydrology and therefore physical, chemical and ecological conditions within the reach. Flow alteration via impoundment, withdrawal or discharge is relatively rare in Alaska, but does occur. Flow alteration within the project area can also be a result of land cover changes throughout the catchment and altered floodplain capacity (e.g., road embankments, levees, and altered riparian areas) along the contributing stream length. Various aspects of the flow regime are not specifically defined, and analysis will depend on available data of existing flow conditions along with identified project goals.

Catchment assessment ratings: A catchment in good condition has a natural flow regime with little to no flow reduction or augmentation occurring upstream of the project reach; flow stages and volumes are within 10% of the natural flow condition (Richter et al. 2012). If there are multiple lines of evidence indicating the reach hydrology is moderately or substantially altered from the natural condition, then the catchment condition would be considered fair or poor, respectively. A catchment in poor condition has stream flows that are heavily depleted or augmented; water stages and flow volumes are more, or less, than 20% of the natural flow condition.

Data Collection: Catchment-scale information can be used to inform conclusions about flow alteration, including dam density, anthropogenic land cover, the density of roadside ditches, and active points of diversion. Information is available from Alaska Department of Natural Resources and ADF&G on dams<sup>12</sup>, water rights<sup>13</sup>, and instream flow reservations<sup>14</sup>. Users should also walk as much of the upstream channel as possible looking for evidence of reduced floodplain capacity (e.g., levees).

In addition, consultation with the land manager, Alaska Department of Environmental Conservation, Alaska Division of Mining, Land and Water, or Alaska Department of Fish and Game may yield additional information regarding altered flow.

## **9. Roads and Trail Networks**

The presence of roads and trails adjacent to or crossing a stream often affects existing condition and/or limits restoration potential of the stream. Embankments that cross a valley severely alter hydraulics, filling in the floodplain and forcing floodwaters through and over structures, while roads themselves can directly connect impervious or compacted surfaces to the stream channel. Floodplains are reduced and riparian areas cleared where roads and trails share the valley bottom with the stream or river. Roads and trails along hillslopes also lead to altered runoff and increased sediment supplies.

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<sup>11</sup> Google Earth or high-resolution digital imagery is available from DigitalGlobe. DigitalGlobe imagery is available for purchase but is free for federal employees.

<sup>12</sup> <http://www.adfg.alaska.gov/index.cfm?adfg=habitatoversight.Hydroelectric>

<sup>13</sup> <http://dnr.alaska.gov/mlw/water/data/map/>

<sup>14</sup> <https://www.fws.gov/alaska/pages/wetlands/water-resources>

Catchment assessment ratings: Evaluating this category is primarily based on proximity of roads and trails to streams. Catchments in poor condition have roads or trails located near the stream and within the floodplain. As a result, roads/trails directly alter runoff processes; sediment loading, transport, and deposition; channel morphology and stability; water quality; and riparian conditions within the catchment. An example of a poor rating is a stream that shares its valley with a road and is cut off from half of the floodplain. This encroachment on the floodplain occurs in proximity, or even along the project area. A fair rating is given when the stream shares its valley with a road but further from the project area such that impacts are reduced. Another example of a fair catchment is the presence of roads located outside of the stream valley but along hilltops or hillslopes, accelerating hillslope erosion processes. Catchments in good condition typically do not have roads or trails.

Data Collection: The presence of roads or trails can be determined in the field, using available aerial imagery, or Geographic Information System (GIS) data. GIS data are available from the Alaska Department of Transportation (ADOT)<sup>15</sup> and BLM<sup>16</sup> websites.

The Watershed Assessment of River Stability and Sediment Supply (WARSSS; Rosgen 2006) provides a more detailed method for evaluating the sediment impact risk of roads. The result provides an overall risk rating that could be used to determine the Watershed Assessment rating (See Figure 4-6 in Rosgen, 2006).

## **10. Urbanization**

This category considers temporal patterns that can affect existing and future conditions and create a moving target for stream restoration. Land use is temporally variable and watersheds that are currently in good or fair condition can degrade quickly in response to development. Active construction within a watershed can cause erosion and increase sediment supply to streams. Urban and residential development can drastically change the hydrology and decrease the quality of water coming into the stream.

Catchment assessment ratings: A catchment in good condition consists of primarily natural land cover, or rural communities with slow growth potential. Catchments evaluated as poor in this category, such as urbanizing communities, have ongoing development or imminent large-scale development. Fair conditions are characterized as low density or rural communities or slow urban or suburban growth.

Data Collection: The rate of urbanization in the watershed can be estimated using the percent increase of impervious cover. Trends in land use can be determined through examining time-series aerial imagery (e.g., Google Earth or USGS Earth Explorer<sup>17</sup>) or by examining land cover data available online through the National Land Cover Database (NLCD).<sup>18</sup> The NLCD includes datasets for percent impervious cover, developed, and forested land from 1992, 2001, 2006, 2011, and 2016.

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<sup>15</sup> <http://dot.alaska.gov/stwdplng/mapping/>

<sup>16</sup> There is a Ground Transportation Linear Features layer available here:  
<https://www.blm.gov/services/geospatial/GISData/alaska#data>

<sup>17</sup> <https://earthexplorer.usgs.gov/>

<sup>18</sup> <https://gapanalysis.usgs.gov/gaplandcover/data/download/>

Zoning designations and development plans can also be obtained from local governments and assessed for the project catchment. ADOT maintains a list of upcoming projects and future plans that should be reviewed for activity in the project catchment.<sup>19</sup>

## **11. Resource Development: Oil, Gas, Wind, Pipeline, Mining, Timber Harvest, Roads**

Development near the project site can significantly affect the existing condition and impact the restoration potential of a stream, depending on the type of development and its proximity to the project site. This category addresses large-scale land uses common to Alaska that are often independent from urbanization, including mining, pipelines, energy development and infrastructure (oil, gas, and wind), and timber harvest. For example, infrastructure associated with energy development adjacent to, or crossing, a project reach is a design constraint that may limit the restoration potential of the project.

Catchment assessment ratings: This category asks the user to assess whether activities are likely to occur within a 1-mile (1,609 meter) radius of the project, and the potential for those activities to adversely affect stream function. Existing or planned development with a high potential to impact the project reach would include sites that are significant sources of contaminants and/or sediment during rain events. The 1-mile radius is approximate and should not extend into neighboring watersheds. Catchments in good condition have no develop and no potential for impacts. Catchments in poor condition have development with a high potential to impact the project reach. Where development can be characterized as moderate, or the negative impact of the development on the project reach are uncertain, the catchment is considered in fair condition.

Data Collection: Resource development near the project site can be determined in the field, using available aerial imagery, or other spatial data. Users should contact the local BLM, DNR, and USACE office for information about mining operations or other permitted activities upstream of the project reach.

## **12. Aufeis**

Woo (2012) defines overflows (a.k.a., icings) as the freezing of water that seeps from the ground, flows from a spring or emerges from beneath a river bed or through fractures in river ice. Icings are not restricted to **permafrost** areas. In Alaska, icings are commonly referred to as the German word **aufeis**, which means “on ice” or “top ice.” Daly et al. (2011) defines aufeis as ice that is formed from the freezing of successive flows of water over previously formed ice. Carey (1973) characterizes aufeis in three categories based on their mode of occurrence: ground, spring, and river. Aufeis is a natural process that can be altered by human activities that remove vegetation and change the topography, thus altering water flow and thermal regulation. Carey (1973) explained that ground icing is rare in undisturbed landscapes but can become the dominant form of icing in disturbed landscapes. Groundwater seeping from cut slopes, such as highways or even trails, can spread across the ground surface and freeze. Often, these disturbances create a discharge point for groundwater flowing between the frozen upper portion of the active layer and the permafrost below. Hydrostatic pressure forces the water up onto the land surface. As the hydrostatic pressure and volume of flow increases, the thickness of the aufeis increases. River and spring aufeis can be exacerbated by large land clearing and grading operations, such as placer mining. Unnaturally high levels of aufeis in disturbed landscapes can

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<sup>19</sup> [http://dot.alaska.gov/project\\_info/index.shtml](http://dot.alaska.gov/project_info/index.shtml)



lead to channel and floodplain instability. For example, aufeis development on one side of a stream channel can increase stream flow against the opposite bank. If that bank is devoid of vegetation, streambank erosion can be extreme (Figure 16).



*Figure 16: Aufeis Example*

Catchment assessment ratings: This category asks the user to assess the extent of aufeis formation specifically caused by land disturbance within and near the project reach. Minor or nonexistent would qualify as a catchment in good condition, while extensive aufeis from land disturbing activities would result in a poor catchment for this category. The catchment is considered fair where aufeis formation caused by land disturbance is moderate within or near the project reach.

Data Collection: This category is evaluated through field visits to identify aufeis and the likely causes. This assessment should occur in spring and early summer; after ice break-up but before all the ice has melted. Aufeis is typically identified in early spring (March/April) and right after snowmelt using drones or snow machines where there is not road access. Field visits right after snow melt can help distinguish aufeis from snow. Where aufeis is present, the determination of whether the cause is anthropogenic or natural can be determined by reviewing aerial imagery and local data for land disturbing activity.

### **13. Permafrost Degradation**

Permafrost, which is found naturally where the ground has been below 0° C for a minimum of two years, is a significant driver of hydrologic processes in Alaska. The presence and extent of permafrost within a watershed impacts infiltration, subsurface storage, subsurface flow (hydraulic conductivity) and therefore flashiness of stream hydrographs. In areas with permafrost, hydrologic characteristics in response to precipitation events will change over the

course of the summer season as the active layer thaws, subsurface storage increases, and baseflow increases steadily. (Bolton et al. 2000)

Therefore, where permafrost is present within the catchment, the consequences of land disturbance activities such as vegetation clearing, and cuts across hillslopes can have an amplified impact on stream function by altering stream hydrology. Permafrost degradation contributes to hillslope slumping, increased erosion, and/or water quality impacts. Permafrost thaw or increases in active layer depth due to climate warming and human disturbances have also led to an increase in the frequency and magnitude of mega slumps, made up of previously frozen sediments, leading to increased sediment and solute inputs into adjacent streams (Chin 2016). With the loss and degradation of permafrost, stream flows will become less responsive to precipitation and headwater streams may become ephemeral (Jones 2010).

Catchment assessment ratings: This category assesses the extent of permafrost degradation in the catchment. A catchment in good condition has no observed areas of permafrost degradation. Poor or fair catchments have areas of permafrost degradation within or upstream of the project reach.

Data Collection: Potential for presence of permafrost can be determined by looking at permafrost mapping; there are basic maps available online and older, more detailed mapping may be available in some areas (e.g., Fairbanks). Field indicators for the presence of permafrost can include aspect, landscape position, and vegetation signatures. Shallow permafrost can also be identified with a shovel or soil probe in late summer (i.e., after mid-August on most sites).

Once permafrost presence is determined, users should review recent aerial imagery<sup>20</sup> of the catchment and walk as much of the site and nearby streams (upstream and downstream), observing conditions in the valley bottom and the valley slopes, looking for evidence of permafrost and permafrost degradation. Evidence of thermal degradation at sites with permafrost can include thermokarst topography, slumping hillslopes, tipping trees, seeps or springs with excessive sediment discharge, and areas of wetland contraction or expansion not related to beaver or human activity.

#### **14. Other**

This option is provided for the user to identify and document any stressor observed in the catchment that is not listed above but could limit the restoration potential or impair the hydrologic functioning of the project reach. An example could be a specific contaminant of particular interest (rated using category 4 but more detail could be provided in this category) or specific conductivity downstream of a coal mine.

## **2.4 Data Collection for Site Information and Reference Selection**

The condition assessments in the Quantification Tool worksheet of the SQT workbook and the Existing and Proposed Conditions worksheets in the Debit Calculator workbook use reference curves to translate measured field values into index scores. For some metrics, these curves are stratified by physical stream characteristics like stream slope and ecoregion. The Site

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<sup>20</sup> Google Earth or high-resolution digital imagery is available from DigitalGlobe. DigitalGlobe imagery is available for purchase but is free for federal employees.

Information and Reference Selection section of these worksheets consists of general site information and classifications to determine which reference curves are used to calculate index values for relevant metrics. Information on each metric and guidance on how to select values is described below. Metrics will not be scored or may be scored incorrectly if required data are not provided in this section. Note that incorrect information in the Site Information and Reference Selection section may result in applying reference curves that are not suitable for the project.

For fields with drop-down menus, if a certain variable is not included in the drop-down menus, then data to inform index values for that variable are not yet available for the Alaskan Interior. Additional information on how reference curves are stratified is included in the Scientific Support for the AKSQTint (Steering Committee 2021).

- The project name, reach ID, restoration potential, and reference stream type are automatically populated from the Project Assessment and Catchment Assessment worksheets in the SQT workbook.
- The reach ID, flow type, and Strahler stream order are automatically populated from the Project Assessment worksheet in the Debit Calculator workbook.

Existing Stream Length (ft) – Existing stream length is the centerline distance extending from the upstream to the downstream end of the project reach before any restoration/impact activities occur. This can be determined by surveying the profile of the stream, stretching a tape in the field, or remotely by tracing the stream centerline pattern from aerial imagery. Stream length is not used for reference curve stratification but is used to calculate functional feet. This information is entered in the Debit Calculator worksheet of the Debit Calculator workbook.

Proposed Stream Length (ft) – Proposed stream length is the centerline distance extending from the upstream to the downstream end of the project reach after restoration/impact activities occur. The proposed length can be estimated from project design documents, and later verified using as-built conditions using the approaches described in Existing Stream Length above. Where stream length does not change post-project, the same value can be entered for the Existing and Proposed Stream Length. Stream length is not used for reference curve stratification but is used to calculate functional feet. This information is entered in the Debit Calculator worksheet of the Debit Calculator workbook.

Existing Stream Type (SQT workbook only) – The existing Rosgen stream type (Rosgen 1996) is determined through a field survey of the project reach. This stream classification system and the basic fluvial landscapes in which the different stream types typically occur are described in detail in *Part 654 Stream Restoration Design National Engineering Handbook* (NRCS 2007). The existing stream type is not used to select the appropriate reference curve or determine index values but is provided for communication and to inform channel evolution scenarios and reference stream type selection.

Reference Stream Type – Reference stream type represents the stream type that should occur in a specific landscape setting given current hydrogeomorphic watershed- and reach-scale processes. Refer to Section 2.2 for further instruction. Reference stream type is used to stratify reference curves for entrenchment ratio, pool spacing ratio, and pool depth ratio metrics.

Valley Type – Valley type is used to stratify reference curves for riparian extent. The valley type options are unconfined alluvial, confined alluvial, or colluvial/v-shaped.



- Unconfined alluvial valleys – Wide, low gradient (typically less than 2% slope) valleys that support meandering and anastomosed stream types (e.g., C, E, D<sub>A</sub>). In alluvial valleys, rivers adjust pattern without intercepting hillslopes. These valleys typically have a valley width ratio greater than 7.0 (Carlson 2009) or a meander width ratio (MWR) greater than 4.0 (Rosgen 2014).
- Confined alluvial valleys – Valley formed by the deposition of sediment from fluvial processes, typically confined by terraces or hillslopes that supports transitional stream types between step-pool and meandering or where meanders intercept hillslopes (e.g., C, Bc). These valley types typically have a valley width ratio less than 7.0 and a meander width ratio (MWR) between 3 and 4.
- Colluvial/V-shaped valleys – Valley formed by the deposition of sediment from hillslope erosion processes. Colluvial valleys are bowl-shaped and typically confined by terraces or hillslopes. Colluvium is material that originates on the hillslopes and moves through mass wasting processes to the valley bottom where the material interacts with stream flow. These valleys are confined and support straighter, step-pool type channels (e.g., A, B, Bc, F). These valley types typically have a valley width ratio less than 7.0 and a meander width ratio (MWR) ratio less than 3. V-shaped valleys are often found in steep gradient headwater valleys.

Drainage Area (sq.mi.) (SQT workbook only) – The drainage area is the land area draining water to the downstream end of a project reach and is delineated using available topographic data (e.g., USGS maps, LiDAR or other digital terrain data). The drainage area is not used to stratify any reference curves but is important information to consider for bankfull verification (Section 2.6).

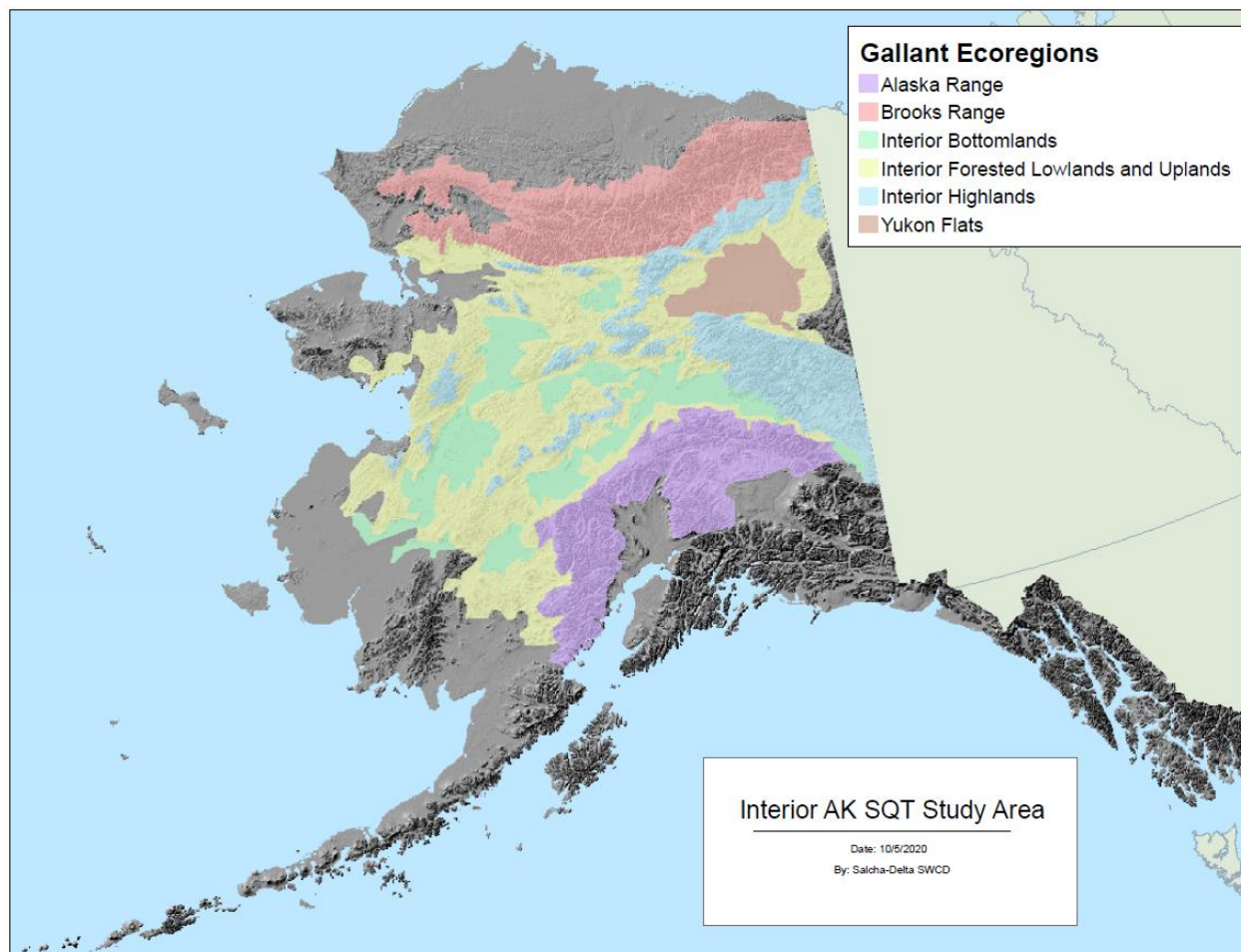
Strahler Stream Order – Stream order as defined by Strahler (1957) is a classification based on stream/tributary relationships. Headwater streams are first order; a stream is second order downstream of the confluence of two first order streams; a stream is third order downstream of the confluence of two second order streams; and so on. Stream order is not used for reference curve stratification but is used to provide context to the change in functional feet in the Mitigation Summary table.

Flow Type – Select whether the stream reach is Perennial, Intermittent, or Ephemeral (see glossary). Flow permanence provides context to the change in functional feet in the Mitigation Summary table and is not used for reference curve stratification.

Proposed Bed Material – Proposed bed material represents the D<sub>50</sub> of a reach-wide pebble count. The selection should be based on the proposed condition, so if the existing condition has sand and the proposed condition is gravel dominated, the selection should be gravel. The AKSQTint uses bed material to select the correct reference curves for the percent fines <2mm metric.

Proposed Slope (%) –The stream slope is a reach average and not the slope of an individual bed feature, e.g., a riffle. The AKSQTint uses stream slope to select the correct reference curves for the percent riffle metric.

**Ecoregion** – EPA Level III ecoregions (Gallant et al. 1995) of the Alaskan Interior are depicted in Figure 17. The AKSQTint uses the project's ecoregion to stratify reference curves for the large woody debris frequency and vegetative complexity metrics.



**Figure 17: Ecoregions for the Alaskan Interior**

**Fish Assemblage** – The user should select whether the project reach is habitat (spawning, rearing, or migration) for anadromous fishes, or habitat solely for non-anadromous species. ADF&G is responsible for maintaining an anadromous waters catalogue (AWC) that can be consulted first to determine whether the project reach is important to the spawning, rearing, or migration of anadromous fish.<sup>21</sup> However, the AWC is not comprehensive and users should consult with ADF&G regarding the project area. Note, anadromous waters are protected by sections of AS 16.05.871, and persons are required to obtain a Fish Habitat Permit prior to performing any activity that would take place in specified water bodies. The AKSQTint uses the assemblage input to stratify reference curves for the fish species richness metric.

<sup>21</sup> <https://www.adfg.alaska.gov/sf/SARR/AWC/index.cfm?ADFG=main.interactive>

**Reference Vegetation Cover** – The user should select the reference vegetation cover as herbaceous, scrub-shrub, forested, or tundra. The reference vegetation cover is the community that would occur naturally at the site if the reach were free of anthropogenic alteration and impacts. The appropriate reference community type can be determined by locating a similar pristine or minimally altered reference reach within the catchment area or watershed, researching historical and ecological descriptions of mature and undisturbed vegetation communities in the vicinity, and deduced through understanding the effects of land use practices and management on vegetation communities. This input is not used for reference curve stratification but is important information to include for a project site.

## 2.5 Parameter and Metric Selection

The SQT and Debit Calculator workbooks include 28 metrics used to quantify 14 parameters. Not all metrics and parameters will need to be evaluated at each site. The user should consider landscape setting, process drivers, function-based goals/objectives, and restoration potential when selecting parameters.

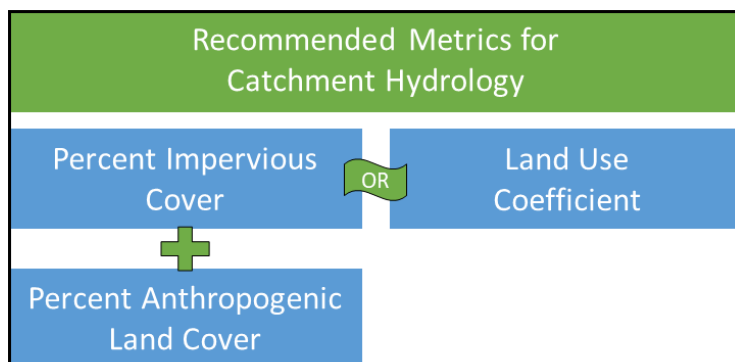
A basic suite of metrics within 6 parameters are required for all single-thread project reaches to set the foundation for a stable channel and floodplain. The basic suite of metrics includes metrics within the reach runoff, floodplain connectivity, flow dynamics, lateral migration, bed form diversity, and riparian vegetation parameters. Note, the bed form diversity parameter is not applicable in bedrock-controlled channels and should not be evaluated. Assessment of the basic suite of metrics is considered rapid, as field data can be collected by a team of 2 in less than a day. Additional metrics may require more time in the field.

### ***Important Considerations:***

- This version of the AKSQTint is regionalized for single-thread, wadeable streams in non-glacial alluvial and colluvial valleys in the Alaskan Interior. Reference curves to assign index values have been primarily derived from data collected from perennial, single-thread stream systems.
- For CWA 404 projects, the Corps has discretion over which field methods, metrics, and parameters are used for a project. Users should consult with the Corps prior to data collection on a project.
- The same parameters must be used in the existing condition and all subsequent condition assessments (i.e., proposed, as-built, and monitoring) within a project reach, otherwise the relative weighting between metrics and parameters changes and the SQT output is not comparable over time.
- For metrics that are not selected, the metric is not included in the scoring. **Users should not enter field values for metrics that were not selected or evaluated.**
- The overall scores should not be compared or contrasted between sites when parameters and metric selection varies between project sites. To evaluate multiple sites, the same suite of parameters and metrics would need to be collected at all sites.

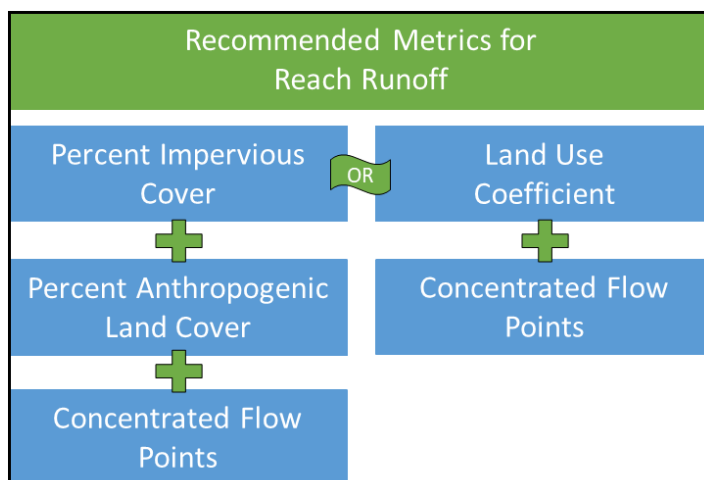
**Specific guidance on parameter selection:**

Catchment Hydrology – This parameter is optional and can be used where the project area includes a significant portion of the catchment. Users should select either the land use coefficient metric or the combination of impervious cover and anthropogenic land cover metrics (Figure 18). Land use coefficient provides/requires more detail in delineating land uses and may be better suited to smaller catchments.



**Figure 18: Metric Selection for Catchment Hydrology**

Reach Runoff Parameter – This parameter should be evaluated at all project sites. The land use coefficient metric and the concentrated flow points metric should be evaluated together. Similar to catchment hydrology, the impervious cover and anthropogenic land cover metrics can be used together instead of the land use coefficient metric (Figure 19).



**Figure 19: Metric Selection for Reach Runoff**

Floodplain Connectivity Parameter – This parameter should be evaluated at all project sites. Users should evaluate both the bank height ratio (BHR) and entrenchment ratio (ER) metrics, except in A reference stream types, where the BHR should be applied alone. Entrenchment

ratio characterizes the horizontal extent of the floodplain while BHR characterizes the frequency of floodplain inundation.

Flow Dynamics Parameter – This parameter should be evaluated at all project sites. There is only one metric to assess this parameter.

Large Woody Debris (LWD) Parameter – This parameter is required where the upstream watershed or adjacent land area naturally support, or historically supported, trees large enough to produce LWD. This parameter is not applicable to streams above tree line or that otherwise naturally have a limited supply of LWD. There is only one metric to assess this parameter.

Lateral Migration Parameter – This parameter should be evaluated at all project sites. Users should evaluate the dominant BEHI/NBS and percent erosion metrics together. The dominant BEHI/NBS characterizes the magnitude of bank erosion, while percent erosion characterizes the extent of bank erosion within a reach.

The percent armoring metric should be applied in addition to the other metrics whenever man-made armoring is present or proposed in a project reach. Note that for project reaches where armoring exceeds 50% of the total bank length, the parameter will score a 0.00 and other metrics may not need to be assessed.

Bed Material Characterization Parameter – This parameter is optional and is recommended for alluvial or confined stream reaches where altered sediment transport processes have shifted the grain-size distribution away from the reference standard condition. This parameter is not applicable in natural sand or silt bed streams.

Bed Form Diversity Parameter – This parameter should be evaluated at all project sites, except natural bedrock systems where the pool spacing ratio would not apply. Users should evaluate pool spacing ratio, pool depth ratio, and percent riffle metrics together.

Riparian Vegetation Parameter – This parameter should be evaluated at all project sites. Users should evaluate riparian extent and vegetative complexity at all sites. The percent native cover metric is optional and can be added where there are non-native species present or likely to be present.

Temperature, Turbidity, and Diatoms Parameters – These parameters are optional for restoration projects and are recommended for projects with goals and objectives related to water quality improvements or projects where improvements to these parameters are anticipated based on restoration potential. One or more parameters can be applied at the project area. Selection and sampling of a reference reach is required for temperature and turbidity and highly encouraged for the diatoms metric (Section 2.5.1). The Diatom Index metric is considered provisional for this version of the AKSQTint, refer to Section 2.10.3 for more information.

Note that the turbidity parameter is only applicable in naturally clear systems.

For impact projects, users can decide whether to measure physicochemical and biology functions or accept the default score for these functional categories.

Macroinvertebrates Parameter – This parameter is optional for restoration projects and is recommended for projects that have goals and objectives related to biological improvements or projects where improvements in biological condition are anticipated based on restoration

potential. Selection and sampling of a reference reach is highly encouraged for this metric (Section 2.5.1).

For impact projects, users can decide whether to measure physicochemical and biology functions or accept the default score for these functional categories.

**Fish Parameter** – This parameter is optional for restoration projects and is recommended for projects that have goals and objectives related to native fish restoration. These metrics could also be required for development projects that are likely to result in functional loss in priority conservation areas or other valuable fish species or habitats.

The fish species richness, relative abundance, and species biomass metrics should be applied together. Selection and sampling of a reference reach is required for all three metrics (Section 2.5.1). Per ADF&G requirements fish sampling for biomass estimates will be restricted in anadromous streams with adult salmon. Therefore, the species biomass metric should not be applied to stream reaches that provide salmon spawning habitat.

For impact projects, users can decide whether to measure physicochemical and biology functions or accept the default score for these functional categories.

### 2.5.1 Reference Reaches

The temperature, turbidity, and fish parameters require sampling in a reference reach. These metrics have field values that are reported as the ratio between observed and expected (O/E), where the expected value is the value from a reference reach. The reference reach should be of reference standard quality with regard to physicochemical and biology processes being assessed and should not represent best attainable for the project reach.

As noted in Section 1.2 of this manual, the AKSQTint relies on reference curves to relate point-in-time condition measurements to functional capacity and standardize all metrics *to an ecologically relevant scale*. Functioning values mean that a metric is quantifying the functional capacity of one aspect of a function-based parameter in a way that is anticipated to support aquatic ecosystem structure and function. Reference standard reaches exhibit the highest level of function for the metric being assessed, and condition ranges from least disturbed to pristine condition. This is comparable to the “Natural Condition” defined by 18 AAC 70.990(41). Selection of reference reaches for determining the expected value in an O/E ratio should follow the guidance below:

- Values derived from the reference reach (e.g., fish species biomass) must be comparable to the natural condition for the project site. It is helpful to understand the ultimate source of natural background levels of parameter, refer to individual metric instructions for guidance (Chapter 2). The relevant processes at the reference reach should be unaltered, or minimally altered, by anthropogenic activities with little to no human activity documented since historic records have been kept.
- Reference reaches for physicochemical parameters would preferably be upstream or within the same watershed as the project reach. A reference reach for the fish or physicochemical parameters should be geographically proximate to the project reach but outside the influence of the project actions.



- The reference reach must have similar aquatic life habitats, geomorphology, hydrology, elevation, and geology to the project reach. If the reference reach is not located upstream or downstream of the project reach, particular attention must be given to this criterion to ensure reference reach selection is reasonable.

The temperature, turbidity, and fish parameters *require* sampling in a reference reach. For the remaining physicochemical and biology parameters, diatoms (provisional) and macroinvertebrates, monitoring in a reference reach is highly encouraged but not required. Data from a reference reach can also inform the expected width/depth ratio for the flow dynamics parameter. In general, identifying and characterizing a reference reach can inform reference stream type, restoration potential, and proposed condition field values within the AKSQTint.

## 2.6 Bankfull Identification and Verification

Bankfull is a discharge that forms, maintains, and shapes the dimensions of the channel as it exists under the current climatic regime. The bankfull stage or elevation represents the break point between channel formation and floodplain processes (Wolman and Leopold 1957). Correctly identifying bankfull is crucial, and the user should identify and verify bankfull using multiple lines of evidence. **The primary lines of evidence are always field indicators as described in Section 2.6.1.** Field indicators of bankfull should be verified using regional curves (Section 2.6.2) or return interval analyses (Section 2.6.3).

Bankfull stage and bankfull dimensions are required to calculate field values for several metrics, including bank height ratio (BHR), entrenchment ratio (ER), width/depth ratio state, dominant bank erosion hazard index/near-bank stress (BEHI/NBS), pool spacing ratio, and pool depth ratio. Additionally, the SQT uses bankfull to identify the representative sub-reach length.

Bankfull identification should be performed by professionals with a background in geomorphology and the necessary experience to accurately complete the methods described here. Bankfull discharge modeling and return interval calculations should be performed by engineers or hydrologists with experience with hydrologic and hydraulic modeling in Alaska.

### 2.6.1. Lines of Evidence – Field Indicators

Methods for identifying the bankfull stage and calculating the bankfull dimensions can be found in Harrelson et al. (1994) and Rosgen (2014). Bankfull indicators should be identified throughout the entire project reach and can be surveyed using rapid or detailed methods. The detailed method requires a longitudinal profile while the rapid method measures the difference in elevation between bankfull indicators and the water surface elevation. Rosgen (2014) provides step-by-step instructions on how to survey a longitudinal profile and compare best-fit-lines through the water surface and bankfull points. The bankfull determination is suspect if the bankfull slope is different from the water surface slope and/or if the best-fit line through the bankfull points has a correlation coefficient ( $R^2$  value) of less than 0.80. For the rapid method, bankfull determination is suspect if the difference between bankfull indicators and water surface elevation varies by more than two to three tenths. If values vary by more than this, the practitioner may be including other geomorphic features, such as an inner berm or a terrace.



In addition to the longitudinal profile, a cross-section must be collected from a stable riffle within the study reach. Rosgen (2014) and Harrelson et al. (1994) provide detailed methods on how to survey a cross section. Rapid methods are provided in Appendix A.

Selection of the stable riffle is critical; the criteria below can aid in the selection of a suitable riffle:

- Stable width and depth, no signs of bank erosion or headcutting. The bank height ratio is near 1.0.
- The cross-sectional area plots within the range of scatter used to create the regional curve. More information is provided in the next section.
- The bankfull width/depth ratio is on the lower end of the range for the reach.
- Note: In a highly degraded reach, a stable riffle cross section may be used from an **adjacent** upstream or downstream reach. If a stable riffle is still not identified, the bankfull width and mean depth from the regional curve should be used.

The surveyed dimensions from this cross-section are used to calculate bankfull cross-sectional area, width, and mean depth. Bankfull discharge can also be calculated from the stable riffle cross-section if channel slope and bed material samples have been collected. A variety of single-section analyzers are available for calculating discharge using the cross-section survey, average slope, and bed material data. The Reference Reach Spreadsheet version 4.3 developed by Dan Mecklenburg with the Ohio Department of Natural Resources is a free, user-friendly tool that will calculate discharge, entrenchment ratio, and several other hydraulic variables.<sup>22</sup>

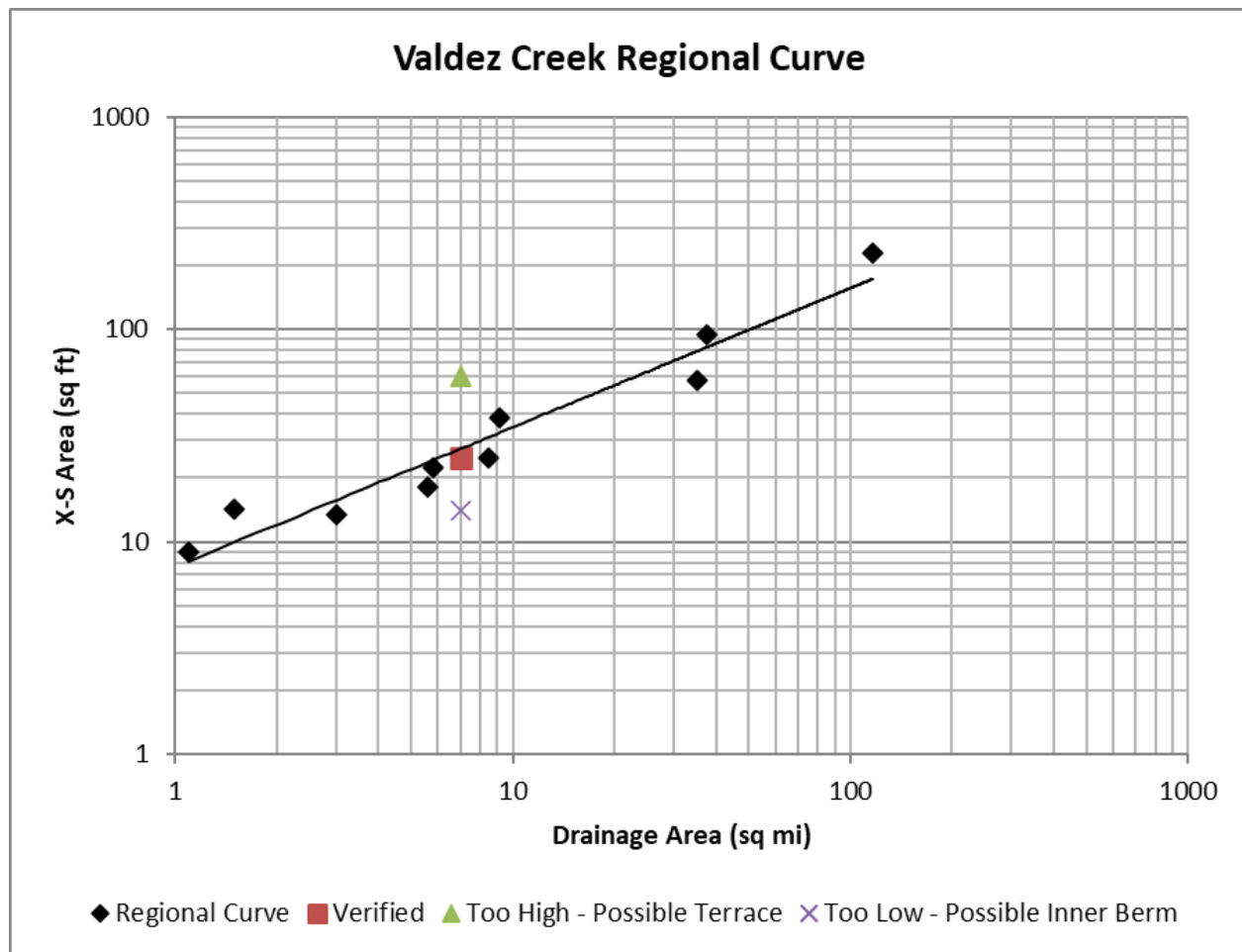
## 2.6.2. Lines of Evidence – Regional Curves

Due to the range of climatic conditions and underlying geology, regional curves can vary significantly throughout the state. Regional curves can only be used when they are applicable to the project site. Ideally, practitioners will develop site-specific regional curves representative of the project catchment. If catchment-specific regional curves are not available, the user can overlay the field data with established curves. Resources for regional curves within Alaska are provided in Harman (2018).

The cross-sectional area(s) from stable riffle(s) are plotted on their corresponding bankfull regional curve (Figure 20). The field data should fall within the range of scatter of the regional curve. If the field data are outside the range of scatter, the practitioner will need to determine if the wrong indicator was selected, e.g., an inner berm or terrace, or if the regional curve represents a different hydro-physiographic region. If the measured area plots below the range of scatter, the indicator could be an inner berm feature. If the measured area plots above the range of scatter, the feature could be a terrace.

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<sup>22</sup> The spreadsheet is available at <https://stream-mechanics.com/resources/> under spreadsheet tools.



*Figure 20: Example of bankfull verification using a regional curve*

### 2.6.3. Lines of Evidence – Return Interval

The standard procedure for estimating flood frequency uses the log Pearson frequency analysis as described in Bulletin 17B (Interagency Advisory Committee on Water Data 1982). The program PeakFQ<sup>23</sup> implements the Bulletin 17B procedures (England et al. 2018) for flood-frequency analysis of streamflow records.

The common range of bankfull return intervals is 1.01- to 2-years. If the discharge calculated from the bankfull feature in the surveyed riffle cross-section is between the 1.01- and 2-year return interval discharges, the feature is verified.

<sup>23</sup>

<https://water.usgs.gov/software/PeakFQ/#:~:text=Program%20PeakFQ%20implements%20the%20Bulletin,range%20of%20annual%20exceedance%20probabilities.>

## 2.7 Hydrology Functional Category

There are two function-based parameters to assess hydrology functions: catchment hydrology and reach runoff. Refer to Section 2.5 of this manual for recommendations on when to apply each parameter and metric.

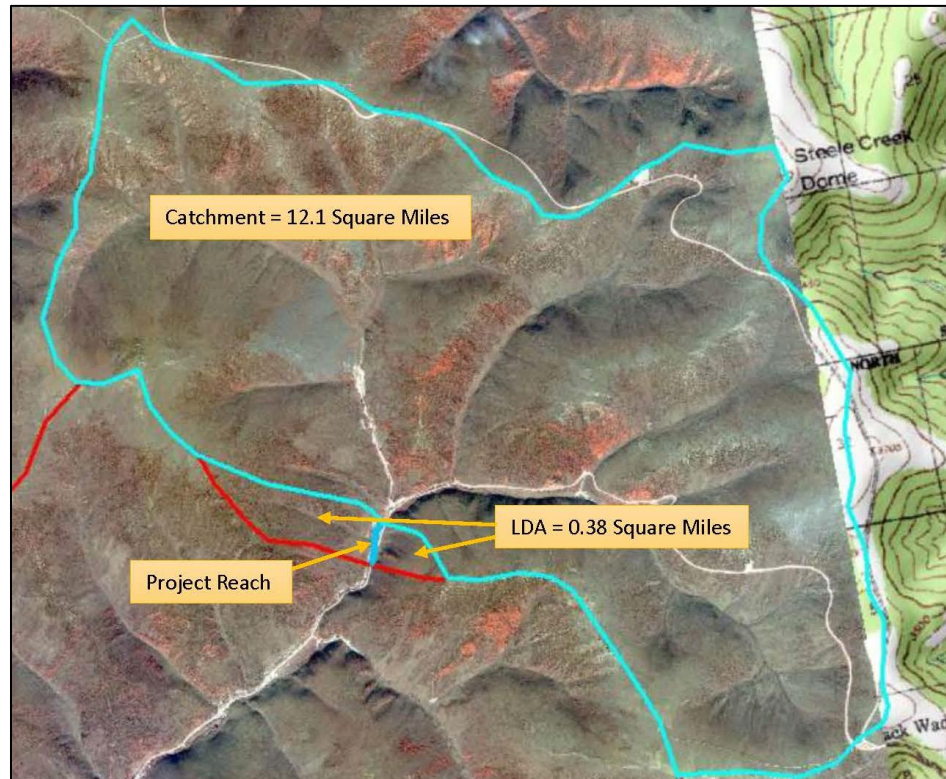
### 2.7.1 Catchment Hydrology & Reach Runoff

**Definition:** The catchment for a project reach is defined as the land area draining to the downstream end of the project reach. The catchment hydrology and reach runoff parameters split the catchment into two portions: The land area that drains to the upstream extent of the project reach and the land that drains laterally into the stream reach (Figure 21).

There are three metrics to assess catchment hydrology: Land use coefficient, percent impervious cover, and percent anthropogenic land cover. There are four metrics to assess catchment hydrology: Land use coefficient, percent impervious cover, percent anthropogenic land cover, and concentrated flow points. Refer to Section 2.5 of this manual for recommendations on when to apply each parameter and metric.

The methods for calculating the land cover metrics are the same for both parameters and are presented below.

**Experience Requirements:** Data collection for catchment hydrology and reach runoff metrics should be performed by professionals with experience in GIS or other spatial analysis software.



*Figure 21: Catchment example showing lateral drainage area (LDA) for Reach Runoff*

### Land Use Coefficient

Land use data can serve as a surrogate for runoff potential and infiltration. Vegetation removal and land cover change alters evapotranspiration, infiltration, and interception volumes, snowpack distribution, and runoff processes.

**Definition:** An area-weighted land use coefficient serves as an indicator of runoff potential from land uses in the upstream catchment (for the catchment hydrology parameter) and lateral drainage area (for the reach runoff parameter) separately. Higher values, nearer 100, indicate more runoff potential while lower values, nearer 0, indicate less runoff. Land use coefficients are shown in Table 6.

**Table 6: Land Use Coefficients.**

Land Use Description	Land Use Coefficient
Mature complex vegetation community	9
Parkland (native herbaceous)	10
Wetland/ shrub-scrub	12
Immature vegetation community	16
Cultivated	18
Vegetation cover, lawn	22
Pasture, gravel with shrubs	31
Unvegetated, disturbed	43
Gravel roads	55
Unvegetated, compacted	60
Drives, walkways	80
Paved streets, impervious	86

### Method:

1. Delineate the catchment and lateral drainage area adjacent to the project reach (Figure 21). Calculate the total [catchment area/ lateral drainage area].
2. Using recent aerial imagery<sup>24</sup> or the USGS National Land Cover Database (NLCD), delineate the different land use types within the [catchment area/ lateral drainage area] and calculate the area occupied by each land use type listed in Table 6.
3. Using Table 6, assign each land use type a land use coefficient value.
4. Calculate an area-weighted land use coefficient for the [catchment area/ lateral drainage area]. For each land use type, multiply the land use coefficient by the area of that land use

<sup>24</sup> Google Earth or high-resolution digital imagery is available from DigitalGlobe. DigitalGlobe imagery is available for purchase but is available at no cost for federal employees.

type; sum all products and divide by the total [catchment area/ lateral drainage area] (see equation below).

$$Land\ Use\ Coefficient_{Area\ Weighted} = \frac{\sum(Area_i * Land\ Use\ Coefficient_i)}{Area_{total}}$$

**Estimating proposed condition field values:** Proposed field values for the land use coefficient can be calculated based on anticipated areas of land use change in the [catchment area/ lateral drainage area] associated with the proposed project. Stream restoration projects may convert land uses within the project area to natural land cover, particularly in the riparian area adjacent to the channel. Keep in mind that newly planted vegetation is considered an immature vegetation community. The area-weighted land use coefficient will change over time as vegetation matures. For a given compensatory mitigation project, performance standards outside the SQT assessment should define when the site can be considered mature (e.g., vegetation density, diversity, diameter at breast height).

### **Impervious Cover**

**Definition:** Impervious cover converts almost all precipitation to runoff and has a disproportionate effect on runoff generation among land use cover classes. Note that this metric does not distinguish between effective impervious area and total impervious cover. Effective impervious cover takes into consideration whether impervious surfaces are directly connected to the receiving stream reach (Booth and Jackson 1997).

**Method:** The impervious cover is calculated by either: 1) delineating all impervious surfaces within a lateral drainage area; or, 2) assuming imperviousness for different land use types and estimating total impervious cover. The former is not practical in larger catchments. Both methods are described below.

1. Delineate the catchment and lateral drainage area adjacent to the project reach (Figure 21). Calculate the total [catchment area/ lateral drainage area].
2. Using recent aerial imagery,<sup>25</sup> delineate the different land use types within the [catchment area/ lateral drainage area] and calculate the area occupied by each type.
  - a. Where practicable, the user can delineate all impervious surfaces within the [catchment area/ lateral drainage area] (e.g., roofs, driveways, streets, parking lots). Note that gravel roads and compacted areas where infiltration processes are limited count as impervious cover.
  - b. In larger lateral drainage areas, where delineating all impervious surfaces is impractical, the user shall delineate areas of different land uses (e.g., agricultural, single family residential, downtown business area, school). The NLCD can be used to estimate percent impervious cover. All assumptions made in selecting impervious percentages for the land use categories shall be documented.
3. Calculate the total percent impervious for the [catchment area/ lateral drainage area].

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<sup>25</sup> Google Earth or high-resolution digital imagery is available from DigitalGlobe. (DigitalGlobe imagery is available for purchase but is free for federal employees.)

**Estimating proposed condition field values:** Proposed field values for the impervious cover metric can be calculated based on anticipated areas of land use change in the [catchment area/ lateral drainage area] associated with the proposed project. Stream restoration projects may convert land uses within the project area to natural land cover, particularly in the riparian area adjacent to the channel.

### *Anthropogenic Land Cover*

**Definition:** Anthropogenic land covers are established and maintained by human effort. Natural land covers are those whose runoff generation processes have not been altered or have been successfully restored. Human alteration of the landscape follows a consistent pattern regardless of whether the conversion supports agricultural, residential, urban, or extractive land uses. The native vegetation is cleared, the site is recontoured to change the slope and/or elevation, and water is moved off the site through grading, ditching, or piped systems.

#### **Method:**

1. Delineate the catchment and lateral drainage area adjacent to the project reach (Figure 21). Calculate the total [catchment area/ lateral drainage area].
2. Using recent aerial imagery<sup>26</sup> or the NLCD, identify all areas within [catchment area/ lateral drainage area] that are anthropogenic (maintained by human effort).
3. Calculate the percent of the [catchment area/ lateral drainage area] that consists of anthropogenic land cover.

**Estimating proposed condition field values:** Proposed field values for the percent of land cover conversion can be calculated based on anticipated areas of land use change in the [catchment area/ lateral drainage area] associated with the proposed project. Stream restoration projects may convert land uses within the project area to natural land cover, particularly in the riparian area adjacent to the channel. For this metric, newly planted vegetation is considered an immature vegetation community and anthropogenic land cover. For a given compensatory mitigation project, performance standards outside the SQT assessment should define when the site can be considered mature (e.g., vegetation density, diversity, diameter at breast height).

### *Concentrated Flow Points*

Anthropogenic impacts can lead to concentrated flows that accelerate storm runoff routing, erode soils, and transport sediment into receiving stream channels. Anthropogenic causes of concentrated flow may include agricultural drainage ditches, impervious surfaces, storm drains, and others (Figure 22).

**Definition:** Concentrated flow points (CFPs) are defined as storm drains, outfalls or erosional features, such as swales, gullies or other channels that are created by anthropogenic impacts. Natural ephemeral tributaries and outlets of properly functioning stormwater best management practices (BMPs) are not considered concentrated flow points in this method (Example 6).

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<sup>26</sup> Google Earth or high-resolution digital imagery is available from DigitalGlobe. (DigitalGlobe imagery is available for purchase but is free for federal employees.)



Best management practices are defined as structural measures that mitigate the hydrologic and physicochemical impacts of anthropogenic land covers.



**Figure 22: Concentrated Flow Point Examples**

**Method:** This metric assesses the number of CFPs that enter the project reach per 1,000 linear feet of stream.

$$\text{CFP} / 1000 \text{ ft} = \frac{\# \text{ CFPs}}{\text{Reach length (ft)}} \times 1000 \text{ ft}$$

1. Review terrain and aerial imagery of the lateral drainage area to identify natural drainages and potential concentrated flow points before going in the field.
2. Walk the **entire project reach**, including both sides of the stream channel, and record the location and type of any observed concentrated flow points.
3. Normalize the number of CFPs counted using the equation above.

**Estimating proposed condition field values:** Proposed field values for this metric can be calculated based on anticipated changes to concentrated flow points in the project area associated with the proposed project. Stream restoration projects may reduce concentrated flow entering the channel by dispersing flow in the floodplain, increasing ground cover near the channel, or by installing stormwater best management practices within the project area. *Combining multiple concentrated flow points into a single concentrated flow point is not considered an improvement.* The restoration activity should diffuse or capture the runoff. Example activities include filling ditches, removing pipes, routing concentrated flow into created or constructed wetlands, and other stormwater control measures.

### *Example 6: Concentrated Flow Points*

The photos below show a newly constructed BMP and the outlet into the Chena River. Over time, the banks of the swale will become vegetated and the swale will slow the runoff from the road and provide some filtration as compared to a storm drain or concrete swale.



## 2.8 Hydraulic Functional Category

There are two function-based parameters to assess hydraulic functions: floodplain connectivity and flow dynamics. Refer to Section 2.5 of this manual for recommendations on when to apply each parameter and metric.

### 2.8.1 Floodplain Connectivity

**Definition:** The floodplain is the area adjacent to the channel that is inundated during overbank flow events. This parameter includes metrics that evaluate whether flows can access, and the extent to which, they access the floodplain.

There are two metrics to assess floodplain connectivity: bank height ratio (BHR) and entrenchment ratio (ER).

**Experience Requirements:** Data collection for floodplain connectivity metrics should be performed by professionals that have experience with standard survey techniques and experience with identification and verification of bankfull.

#### *Bank Height Ratio (BHR)*

**Definition:** The bank height ratio compares the low bank height to the bankfull maximum depth (Rosgen 2014).

**Method:** Prior to calculating this metric, users need to complete the bankfull verification process (Section 2.6).

At every riffle within the representative sub-reach:

1. Measure the length of the riffle (refer to glossary for the definition of a riffle).
2. Identify the bankfull elevation and low bank feature. The bankfull verification process (Section 2.6) should be used to identify the bankfull elevation. For low bank height, identify the break between the channel and a floodplain or terrace on both sides of the stream and identify the bank with the lower elevation. Specific instruction in incised channels is provided below.
3. At the approximate mid-point of the riffle, record the elevation of the low bank elevation and the thalweg elevation. Note, when the low bank elevation and the bankfull elevation are the same, the BHR equals 1.0.
4. Record/calculate the difference between the bankfull elevation and the thalweg elevation (bankfull maximum depth).

Standard survey protocols are required to collect accurate elevation data for Steps 3 and 4 above. Appendix A provides rapid survey instructions using a tape and hand or laser-levels. Other survey protocols are acceptable (e.g., survey grade GPS) provided that accurate elevation data can be obtained to calculate bank height ratio.

5. Calculate the BHR for each riffle by dividing the low bank height (Step 3) by the bankfull maximum depth (Step 4). Record the BHR at each riffle.
6. Using the BHR and riffle length for every riffle feature within the representative sub-reach, calculate the weighted BHR using the equation below and Example 7. The weighted BHR should then be entered in the AKSQTint.

$$BHR_{weighted} = \frac{\sum_{i=1}^n (BHR_i * RL_i)}{\sum_{i=1}^n RL_i}$$

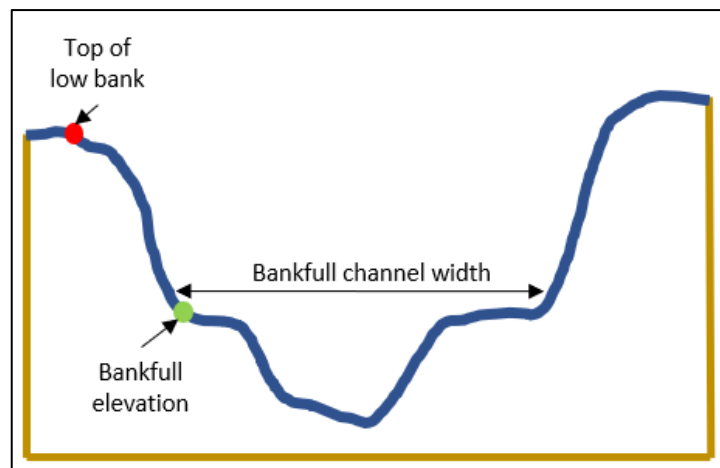
Where,  $RL_i$  is the length of the riffle where  $BHR_i$  was measured.

**Example 7: Weighted BHR Calculation in a representative sub-reach with four riffles**

Riffle ID	Length (RL)	BHR	BHR * RL
R1	25	1.0	25
R2	200	1.5	300
R3	75	1.4	105
R4	40	1.2	36
<b>Total</b>	<b>340 ft</b>	<b>Total</b>	<b>466</b>
Weighted BHR = 466/340 = 1.4			

In incised channels with a bankfull bench, determining when bankfull and the top of bank are equal to each other can be challenging. Two common scenarios are detailed below to aid users in low bank identification:

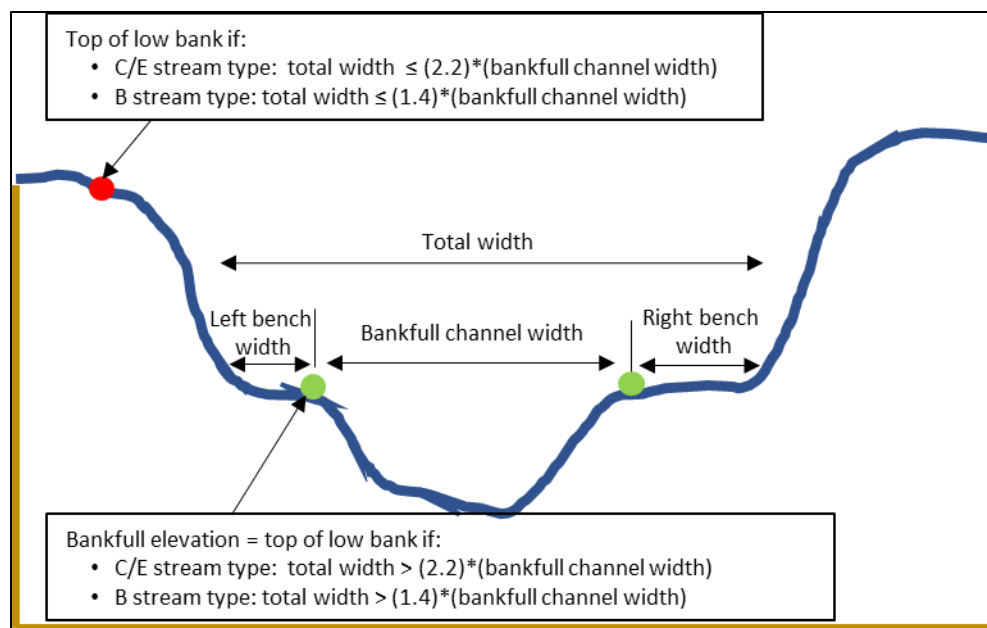
Scenario 1 – If the bankfull elevation is identified as the back of the bench as shown in Figure 23, then the low bank feature is the top of the left bank in the cross-section shown.



*Figure 23: Incised Stream Scenario 1, where bankfull elevation and low bank elevation are not equal.*

Scenario 2 – If the bankfull elevation is identified as the front of the bench as shown in Figure 24, then the width of the bankfull bench(es) must be considered before the low bank feature can be determined.

- For C/E reference stream types, if the total width (left bench + bankfull channel + right bench) is greater than 2.2 times the bankfull channel width, then the low bank feature is equal to bankfull (shown as the green dots in Figure 24).
- For B reference stream types, if the total width is greater than 1.4 times the bankfull channel width, then the low bank feature is equal to bankfull (shown as the green dots in Figure 24).
- If total width is less than or equal to the 2.2 for C/E reference stream types or 1.4 for B reference stream types, then the low bank feature is top of the left bank (shown as the red dot in the cross-section shown in Figure 24).



**Figure 24: Incised Stream Scenario 2, where the width of bankfull benches determine low bank elevation. The green or the red dot can indicate the top of low bank.**

**Estimating proposed condition field values:** The proposed condition field value for BHR should be based on the proposed riffle length and proposed channel cross-section for every riffle in a representative sub-reach of the proposed channel. Calculations should consider any proposed activities that may alter the cross-section or longitudinal profile, including floodplain excavation and construction of berms or levees.

### Entrenchment Ratio (ER)

**Definition:** The entrenchment ratio compares the flood-prone width to the bankfull width at a riffle (Rosgen 2014). The flood-prone width is the cross-section width at a riffle feature **perpendicular to the valley** at an elevation of two times the bankfull riffle maximum depth.

$$ER = \frac{\text{Flood - Prone Width}}{\text{Bankfull Channel Width}}$$

**Method:** Prior to calculating this metric, users need to complete the bankfull verification process (Section 2.6).

The ER should be calculated for each riffle within the representative sub-reach to calculate the weighted ER (see equation below and Example 8). **Note:** If the flood-prone width is uniform (as verified using topographic data), it is unnecessary to measure at every riffle and the entrenchment ratio can be measured at a single representative riffle.

At every riffle within the representative sub-reach:

1. Measure the length of the riffle (refer to glossary for the definition of a riffle).



2. Identify the bankfull elevation. The bankfull verification process (Section 2.6) should be used to identify the bankfull elevation.
3. At the approximate mid-point of the riffle, record the bankfull channel width and flood-prone width.

Standard survey protocols are required to collect accurate dimensions and elevation data for Step 3 above. Appendix A provides rapid survey instructions using a tape and hand or laser-levels. Other survey protocols (e.g., survey grade GPS) are acceptable provided that accurate width measurements can be obtained.

4. Calculate the ER for each riffle by dividing the flood-prone width by the bankfull channel width. Record the ER for each riffle.
5. Using the ER and riffle lengths for every riffle feature within the representative sub-reach, calculate the weighted ER using the equation below and Example 8. The weighted ER should then be entered in the AKSQTint.

$$ER_{weighted} = \frac{\sum_{i=1}^n (ER_i * RL_i)}{\sum_{i=1}^n RL_i}$$

Where,  $RL_i$  is the length of the riffle where  $ER_i$  was measured.

**Example 8: Weighted ER Calculation in a representative sub-reach with four riffles**

Riffle ID	Length (RL)	ER	ER * RL
R1	25	1.2	30
R2	200	2.1	420
R3	50	1.6	80
R4	30	1.8	54
<b>Total</b>	<b>305 ft</b>	<b>Total</b>	<b>584</b>
Weighted ER = 584/305 = 1.9			

**Estimating proposed condition field values:** The proposed condition field value for ER will be based on the proposed riffle length, flood-prone area width, and channel width for every riffle in a representative sub-reach of the proposed channel. Calculations should consider any proposed activities that may alter the flood-prone area, cross-section, or longitudinal profile, including floodplain excavation and construction of berms or levees.

## 2.8.2 Flow Dynamics

**Definition:** The dynamic flow conditions created by the interaction of flowing water against the stream bed and banks (Harman et al. 2012).

There is one metric to assess flow dynamics: width/depth ratio (% of expected).



**Experience Requirements:** Data collection for flow dynamics should be performed by professionals that have experience with standard survey techniques and experience with identification and verification of bankfull.

### **Width/Depth Ratio (% of Expected)**

**Definition:** The width/depth ratio (W/D) is measured as the bankfull channel width divided by the bankfull mean depth. The bankfull mean depth is calculated as the cross-sectional area divided by the bankfull width. This ratio is then divided by a reference W/D. This metric is described as W/D ratio state by Rosgen (2014).

$$Aggradation\ Ratio = \frac{W_{riffle}}{D_{mean\ riffle}} / Reference\ W/D$$

**Method:** Prior to calculating this metric, users need to complete the bankfull verification process (Section 2.6).

At every riffle within the representative sub-reach:

1. Measure the length of the riffle (refer to glossary for the definition of a riffle).
2. At the approximate mid-point of the riffle, identify the bankfull elevation and survey the bankfull cross-section with sufficient detail to calculate bankfull area. The bankfull verification process (Section 2.6) should be used to identify the bankfull elevation.

Standard survey protocols are required to collect accurate elevation data; Appendix A provides rapid survey instructions using a tape and hand or laser-levels. Other survey protocols are acceptable (e.g., survey grade GPS) provided that accurate elevation data can be obtained to calculate W/D.

3. Calculate the bankfull width, cross-sectional area, mean depth, and W/D for each riffle.
4. Using the W/D and riffle length for every riffle feature within the representative sub-reach, calculate the weighted W/D using the equation below.

$$W/D_{weighted} = \frac{\sum_{i=1}^n (W/D_i * RL_i)}{\sum_{i=1}^n RL_i}$$

Where,  $RL_i$  is the length of the riffle where  $W/D_i$  was measured.

5. Determine the reference W/D. Since the W/D can play a large role in the design process and is often linked to slope and sediment transport assessments, the reference W/D is selected by the user. The reference W/D can come from the stable riffle cross-section (Section 2.6), a riffle cross-section at a reference reach (Section 2.5.1), or through the design process. Justification for the selected W/D should be provided.
6. Calculate the field value by dividing the results of Step 4 by the reference W/D (Step 5). This value should then be entered in the AKSQTint.

**Estimating proposed condition field values:** The reference W/D value will remain the same for both the existing and proposed calculations. The proposed condition field value for W/D should be based on the proposed riffle length and proposed channel cross-section for every

riffle in a representative sub-reach of the proposed channel. Calculations should consider any proposed activities that may alter the cross-section, including bank angle and stabilization.

## 2.9 Geomorphology Functional Category Metrics

The AKSQTint contains the following function-based parameters to assess the geomorphology functional category: large woody debris, lateral migration, bed material characterization, bed form diversity, and riparian vegetation. Not all geomorphic parameters will be evaluated for all projects. Refer to Section 2.5 of this manual for recommendations on when to apply each parameter and metric.

### 2.9.1 Large Woody Debris (LWD)

**Definition:** Large woody debris (LWD) is defined as dead wood, standing or fallen, over 4.92 feet (1.5m) in length and at least 3.94 inches (10 cm) in diameter. The wood must be within the bankfull channel or spanning the bankfull channel. LWD that lies in the floodplain but is not at least partially in the active channel is not counted (BLM 2017).

The LWD frequency metric is used to assess LWD in the AKSQTint.

**Experience Requirements:** Data collection should be performed by qualified field teams with training in BLM aquatic AIM protocols.

#### *LWD Frequency*

**Definition:** The LWD frequency metric is a count of the number of LWD pieces throughout the main channel of the representative sub-reach normalized to 328-foot (100 meters) of stream.

**Method:** This metric is derived from data collection procedures outlined in BLM TR 1735-2 Section 7.6 (2017). Refer to source material for complete instructions.

The field value for the AKSQTint is the total number of LWD pieces counted within the representative sub-reach, divided by the length of the sub-reach and multiplied by 328 ft (100m).

$$\text{LWD Frequency} = \frac{\# \text{ LWD Pieces}}{\text{Sub-Reach length (ft)}} * 328 \text{ ft}$$

**Estimating proposed condition field values:** The proposed condition field value is based on the proposed amount and anticipated recruitment of LWD in the project reach. The proposed value should consider the removal of any existing LWD or installation of new LWD that would occur during project construction.

## 2.9.2 Lateral Migration

**Definition:** Lateral migration is the movement of a stream laterally across its floodplain and is largely driven by processes influencing bank erosion and deposition.

There are three metrics for this parameter: dominant bank erosion hazard index (BEHI)/near-bank stress (NBS), percent streambank erosion, and percent streambank armoring.

**Experience Requirements:** Data collection for lateral migration metrics should be performed by professionals with training and experience in applying the BEHI/NBS methods.

### ***Dominant Bank Erosion Hazard Index/Near-bank Stress (BEHI/NBS)***

**Definition:** The Bank Erosion Hazard Index (BEHI) is a method used to estimate the tendency of a given stream bank to erode based on:

1. Bank angle,
2. Riparian vegetation,
3. Rooting depth and density,
4. Surface protection, and
5. Bank height relative to bankfull height.

Near-bank Stress (NBS) is an estimate of shear stress exerted by flowing water on the stream banks. Together, BEHI and NBS are used to populate the Bank Assessment for Non-point source Consequences of Sediment (BANCS) model and produce cumulative estimates of stream bank erosion rates for surveyed reaches (Rosgen 2014).

In the AKSQTint, the BEHI/NBS assessment is used to determine the dominant BEHI/NBS category for eroding banks within the representative sub-reach.

**Method:** Prior to calculating this metric, users need to complete the bankfull verification process (Section 2.6). BEHI/NBS should be evaluated throughout the representative sub-reach.

Follow the guidance in Appendix D of the *Function-Based Rapid Field Stream Assessment Methodology* (Starr et al. 2015), or *River Stability Field Guide, Second Edition* (Rosgen 2014). An optional field form is included in Appendix B for convenience.

1. Measure the bank length of **every** outside meander bend and determine its BEHI/NBS category. The outside of the meander bend is always assessed, even when it is not eroding.
2. Measure the bank length of **any other bank that is actively contributing sediment** and determine its BEHI/NBS category.

Depositional zones, such as point bars, or other areas that are not actively eroding, should not be evaluated (Rosgen 2014). Riffle sections that are not eroding and have low potential to erode are also **excluded** from the AKSQTint BEHI/NBS survey.

**Banks that are armored should not be assessed with the dominant BEHI/NBS metric.** See percent streambank armoring metric for armored banks.

3. Add the length of all assessed banks in the representative sub-reach.
4. Divide the length of each bank by the results of Step 3.

5. Add the percent of assessed bank length for each category (Example 9). The dominant BEHI/NBS is the category that represents the greatest cumulative bank length; it does not need to describe over 50% of the assessed banks.

If there are two or more BEHI/NBS categories with the same total percent, the category representing the highest level of bank erosion should be selected.

To enter the field value in the AKSQTint, a drop-down list of BEHI/NBS categories is provided in the Quantification Tool worksheet.

#### **Example 9: Calculation of Dominant BEHI/NBS**

In this example, data were collected in the field along the left and right banks of a 550-foot representative sub-reach. Within this reach, actively eroding banks and those with a strong potential to erode were assessed using the BEHI/NBS methods.

Bank ID (Left and Right)	BEHI/NBS	Length (Feet)	Percent of Total (%)
L1	Low/Low	50	50 / 155 = 32%
L2	<b>High/High</b>	<b>12</b>	<b>8%</b>
R1	Mod/High	22	14%
R2	<b>High/High</b>	<b>31</b>	<b>20%</b>
L3	Low/Mod	9	6%
R4	<b>High/High</b>	<b>31</b>	<b>20%</b>
<b>Total Length</b>		<b>155</b>	

BEHI/NBS assessments were done on 155 feet of stream bank, out of the total 1,100 feet of streambank within the representative sub-reach. There are four BEHI/NBS categories present. The length of each bank was summed and divided by the total assessed bank length; the total percent is then calculated for each category (e.g., High/High: 8+20+20 = 48). The dominant BEHI/NBS category is High/High since that score is highest and describes 48% of the assessed banks.

**Estimating proposed condition field values:** The proposed condition field value should be based on any anticipated changes to channel bank or hydraulic conditions associated with the project within the representative sub-reach. Note that for the aspects of BEHI that pertain, or could pertain, to riparian vegetation (rooting depth and density, and surface protection) these should be estimated for conditions at project closeout.

#### **Percent Streambank Erosion**

**Definition:** The percent streambank erosion is measured as the length of streambank that is actively eroding divided by the total length of bank (left and right) in the representative sub-reach.

**Method:**

1. Perform the dominant BEHI/NBS assessment methods as described in the previous section.
2. Sum the lengths of all banks within the BEHI/NBS categories that are considered actively eroding (Table 7).

**Table 7: BEHI/NBS Stability Ratings that Represent Actively Eroding and Non-eroding Banks**

<b>Non-eroding Banks</b>	<b>Actively Eroding Banks</b>
L/VL, L/L, L/M, L/H, L/VH, L/Ex, M/VL, M/L	M/M, M/H, M/VH, M/Ex, H/L, H/M, H/H, H/Ex, VH/VL, Ex/VL, Ex/L Ex/M, Ex/H, Ex/VH, VH/VH, Ex/Ex
VL = Very Low, L=Low, M = Moderate, H = High, VH = Very High, Ex = Extreme	

3. Calculate the total length of streambank in the representative sub-reach. This is the sum of the left and right bank lengths, approximately twice the centerline length of the sub-reach.

Note, this value is different from the assessed bank length used to calculate the dominant BEHI/NBS metric (Table 7).

4. Divide the total length of actively eroding bank (Step 2) by the total length of streambank within the representative sub-reach (Step 3). Refer to Example 10.

$$\text{Percent Streambank Erosion} = \frac{\text{Length of eroding bank}}{\text{Total length of streambank}_{\text{sub-reach}}} * 100$$

**Estimating proposed condition field values:** The proposed condition field value should be based on any anticipated changes to channel bank or hydraulic conditions associated with the proposed project within the representative sub-reach. For mitigation projects, this may include an estimate of the expected extent of bank erosion at the end of monitoring, keeping in mind that monitoring events will document whether the proposed condition is achieved. For impact sites, the user must estimate the extent of bank erosion that is likely, considering hydraulic expansion/contraction effects associated with stream crossings. Removing vegetation along the bank is also likely to lead to bank erosion.

**Example 10: Calculation of Percent Erosion**

This example uses the same BEHI/NBS results as above. In the table below, actively eroding banks are identified in bold per Table 11. These bank lengths are summed (12+22+31+31 = 96 feet) and divided by the total bank length (representative sub-reach length of 550 feet \* 2 = 1,100). The total percent streambank erosion is 96 / 1,100 (feet) = 8.7%.

Bank ID (Left and Right)	BEHI/NBS	Length (Feet)
L1	Low/Low	50
<b>L2</b>	<b>High/High</b>	<b>12</b>
<b>R1</b>	<b>Mod/High</b>	<b>22</b>
<b>R2</b>	<b>High/High</b>	<b>31</b>
L3	Low/Mod	9
<b>R4</b>	<b>High/High</b>	<b>31</b>

**Percent Streambank Armoring**

**Definition:** Bank armoring is defined as any rigid human-made stabilization practice that permanently prevents lateral migration processes. Examples of armoring include rip-rap, gabion baskets, concrete, boulder toe and other engineered materials that covers the entire bank height. Bank stabilization practices that include toe protection to reduce excessive erosion are not considered armoring if the stone or wood does not extend from the streambed to an elevation that is beyond one-third the bank height and the remainder of the bank height is vegetated.

**Method:**

1. Walk the **entire reach**, including both sides of the stream channel, and measure the lengths of armored banks.
2. Calculate the total length of streambank in the project reach. The total length of streambank is the sum of the left and right bank lengths within the project reach and can be calculated by multiplying the project reach length by two.
3. Percent streambank armoring field value is calculated by summing lengths of all armored banks within the project reach (Step 1) and dividing by the total length of streambank (Step 2).

$$\text{Percent Armoring} = \frac{\text{Length of armored bank}}{\text{Total length of streambank}_{\text{reach}}} * 100$$

**Estimating proposed condition field values:** The proposed condition field value is based on any additional armoring or armoring proposed to be removed as part of the project. This additional or reduced length should be added to or subtracted from the length of bank armoring measured in the existing condition and divided by the proposed total length of streambank in the reach (proposed reach length multiplied by two).



### 2.9.3 Bed Material Characterization

**Definition:** Bed material consists of the particles between the scour lines on the left and right bank of a channel. Particles are characterized by the measurement of the intermediate axis.

The percent fines < 2mm metric is used to characterize bed material in the AKSQTint.

**Experience Requirements:** Data collection should be performed by qualified field teams with training in BLM aquatic AIM protocols.

#### *Percent Fines < 2mm*

**Definition:** Fines are bed material samples from a project reach that are smaller than 2mm in intermediate diameter.

**Method:** This metric is derived from data collection procedures outlined in BLM TR 1735-2 Section 7.5 (2017). Refer to the source material for complete instructions, the main transects for this method are the same as the transects used for vegetative complexity. Intermediate transects are centered between the main transects.

The field value for the AKSQTint is the number of particles sampled with an intermediate axis less than 2mm divided by the number of particles counted, multiplied by 100.

$$\text{Percent Fines} = \frac{\# \text{ Particles} < 2\text{mm}}{\text{Total} \# \text{ Particles sampled}} * 100$$

**Estimating proposed condition field values:** Bed material is a parameter recommended for projects where fining of the bed material is occurring due to bank erosion or where activities are proposed that could lead to increased or decreased fine sediment deposition over coarse bed material (e.g., gravel). Projects that implement bank stabilization practices along a long project reach or restore flushing flows may be able to show a reduction in fine sediment deposition.

### 2.9.4 Bed Form Diversity

**Definition:** Bed forms include the various channel features that maintain heterogeneity and stability in the channel form, including riffles, runs, pools, and glides (Rosgen 2014). Together, these bed features create important channel patterns and habitats for aquatic life. Riffles and pool types are defined below and more detail on bed feature identification is provided in Appendix A.

There are three metrics for this parameter: pool spacing ratio, pool depth ratio, and percent riffle.

**Experience Requirements:** Data collection for bed form diversity metrics should be performed by professionals that have experience with standard survey techniques, prior field experience identifying fluvial bed forms in the Alaskan Interior, and experience with identification and verification of bankfull. Users should have prior field experience in identifying bedform features sequences in different stream types, including experience differentiating between geomorphic pools and significant pools as defined by the AKSQTint.

### Pool Spacing Ratio

**Definition:** The pool spacing ratio compares the stream length distance between sequential **geomorphic pools** to the bankfull width at a riffle (Rosgen 2014). **Geomorphic pools** are large pools that are associated with planform features and remain intact over time and across a range of flow conditions. Examples include pools associated with the outside of a meander bend (streams in **alluvial valleys**) and downstream of a large cascade or step (streams in **colluvial valleys**). More detail on bed feature identification is provided in Appendix A.

**Method:** Prior to calculating this metric, users need to complete the bankfull verification process (Section 2.6). The bankfull channel width of the stable riffle also needs to be determined prior to calculating this metric (Section 2.6).

1. Record the location along the longitudinal profile of the **maximum pool depth** of every **geomorphic pool** in the representative sub-reach. Measure and record the spacing between the maximum depths of the sequential pools.

Standard survey protocols are required to collect accurate location data of the stream centerline.<sup>27</sup> Appendix A provides rapid survey instructions using tape; other survey protocols (e.g., survey grade GPS) are also acceptable.

2. The pool spacing ratio is calculated for each pair of sequential **geomorphic pools** in the representative sub-reach using the equation below. Note that the bankfull channel width to calculate this metric is from a stable riffle (Section 2.6).

$$\text{Pool Spacing Ratio} = \frac{\text{Distance between sequential geomorphic pools}}{\text{Bankfull channel width}}$$

3. The pool spacing ratio, using the median of all the pool spacing measurements from the representative sub-reach, should be entered as the field value.

When working in streams that have been straightened (channelized), a bed form sequence may not be present. This typically occurs because pool forming processes (meandering and scour processes) have been removed. **In this case, the reach will likely be mostly riffle habitat and the user should enter a field value of 0.0 for this metric.** This result indicates that a bed form sequence should be present based on the reference stream type, but it is absent due to channelization. This situation is most common in channelized streams where the meander width ratio (belt width / bankfull width) is less than 3.5 and the sinuosity is less than 1.2.

**Estimating proposed condition field values:** The proposed condition field value should be based on the proposed channel profile in colluvial valleys and based on the proposed channel profile and meander geometry in alluvial valleys.

### Pool Depth Ratio

**Definition:** Pool depth ratio compares the bankfull pool maximum depth at every **significant pool** to the bankfull riffle mean depth. **Significant pools** include all geomorphic pools (see

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<sup>27</sup> Appendix A field methods instruct users to stretch the tape along the stream bank. Channel centerline and streambank are considered equivalent.

above) and pools that meet the following criteria (adapted from BLM 2017): contained within the main channel; contain the thalweg; are laterally and longitudinally concave; and span at least 50% of the wetted channel at any location within the pool. More detail on bed feature identification is provided in Appendix A.

**Method:** Prior to calculating this metric, users need to complete bankfull verification, evaluate the stable riffle, and calculate the bankfull mean depth (Section 2.6).

At every **significant pool** within the representative sub-reach:

1. Identify the bankfull elevation and pool maximum depth. The bankfull verification process (Section 2.6) should be used to identify the bankfull elevation.
2. Measure and record the difference between the bankfull elevation and the thalweg elevation (bankfull pool maximum depth).

Standard survey protocols are required to collect accurate location data of the stream centerline and elevation data. Appendix A provides rapid survey instructions using a tape and hand or laser-levels, though other survey protocols (e.g., survey grade GPS) are also acceptable.

3. Pool depth ratio is calculated by dividing the bankfull pool maximum depth by the bankfull mean depth from the stable riffle survey.

$$\text{Pool Depth Ratio} = \frac{D_{\text{max pool}}}{D_{\text{mean riffle}}}$$

If a longitudinal profile is generated, the best-fit-line through the bankfull points should be used to calculate the bankfull elevation associated with each pool maximum depth.

For the rapid survey, the difference in bankfull and water surface (established during the bankfull verification process) should be used at each bankfull pool maximum depth location.

4. Average the pool depth ratio values from all **geomorphic** and **significant pools** in the representative sub-reach and enter it as the field value into the AKSQTint.

**Estimating proposed condition field values:** The proposed condition field value should be based on the proposed channel profile in colluvial valleys and based on the proposed channel profile and meander geometry in alluvial valleys.

### **Percent Riffle**

**Definition:** The percent riffle is the portion of the representative sub-reach containing **riffle** features, as distinct from pool features. **Riffles** are shallow, steep-gradient channel segments typically located between pools. Riffles are the river's natural grade control feature (Knighton 1998) and are sometimes referred to as fast-water channel units (Hawkins et al. 1993; Montgomery and Buffington 1998). For purposes of the AKSQTint, in meandering streams riffles broadly represent the section between lateral-scour pools known as a **crossover**, regardless of bed material size. The term riffle also refers to **ripples** in sand bed streams and the cascade section of steep mountain streams. For the percent riffle metric in the SQT, riffles are measured from head of riffle to head of significant pool. The SQT does not distinguish run features from riffles, runs are considered riffles and similarly glides are considered pools. More detail on bed feature identification is provided in Appendix A.

### Method:

1. Measure the length of each riffle in the representative sub-reach from the channel centerline. Riffle length is measured from the head (beginning) of the riffle downstream to the head of a geomorphic or significant pool. **Run features are included within the riffle length.**<sup>28</sup> Riffle length may include riffles with small pools that do not meet the criteria to be considered a significant pool as defined in this manual. Glide features are classified as pools.

Standard survey protocols are required to collect accurate location data of the stream centerline and bed form features. Appendix A provides rapid survey instructions using a tape and hand or laser-levels, though other survey protocols (e.g., survey grade GPS) are also acceptable.

2. Add the length of all riffles within the representative sub-reach. Percent riffle is calculated by dividing the total length of **riffles** within the representative sub-reach by the total representative sub-reach length.

$$\% \text{ Riffle} = \frac{\sum(\text{Riffle length}_{\text{sub-reach}})}{\text{Total length}_{\text{sub-reach}}}$$

**Estimating proposed condition field values:** The proposed condition field value should be based on the proposed channel profile in colluvial valleys and based on the proposed channel profile and meander geometry in alluvial valleys.

## 2.9.5 Riparian Vegetation

**Definition:** Riparian vegetation is defined as the plant communities contiguous to and affected by surface and subsurface hydrology and fluvial disturbance within the stream corridor.

There are three metrics for riparian vegetation: riparian extent (% of expected), vegetative complexity, and percent native cover.

**Experience Requirements:** Data collection for riparian vegetation metrics should be performed by qualified field teams with training in BLM aquatic AIM protocols. A qualified field team must include botanists or professionals with basic knowledge of native and nonnative plants commonly found in riparian zones within the region and who have spent time in the field with a botanist (BLM 2017). Additionally, data collection for riparian extent should be performed by professionals trained to identify riparian areas in Alaska.

### *Riparian Extent (% of Expected)*

**Definition:** Riparian extent is the percentage of the historic or expected riparian area that currently contains riparian vegetation and is free from utility-related, urban, or otherwise soil disturbing land uses, fill, and development.

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<sup>28</sup> A run is a transitional feature from the riffle to the pool and the glide transitions from the pool to the riffle (Rosgen 2014).

This metric characterizes the percent of the reference expectation for that site that is currently occupied by riparian vegetation (observed). The expected and observed values should first be estimated from the desktop and then validated in the field.

$$\text{Riparian Extent} = \frac{\text{Observed Riparian Area}}{\text{Expected Riparian Area}} * 100$$

**Method:** The riparian extent metric relies on a combination of desktop methods and field verification methods. See Example 11 for an example of riparian area delineation and calculation.

1. Estimate the expected and observed riparian area from the desktop using aerial imagery<sup>29</sup>, topographic data, LiDAR, or digital elevation models. More detail on indicators for delineating these features is provided below.
2. Verify the expected and observed riparian area indicators in the field. Where possible, verify the observed and expected riparian extents using tape, a range finder, or by recording the GPS location of the riparian extent.
3. Using desktop measurement tools, delineate the field-verified extent of the expected and observed riparian areas. This area should include the stream channel itself.
4. Calculate the AKSQTint value for riparian extent (%) using the equation above.

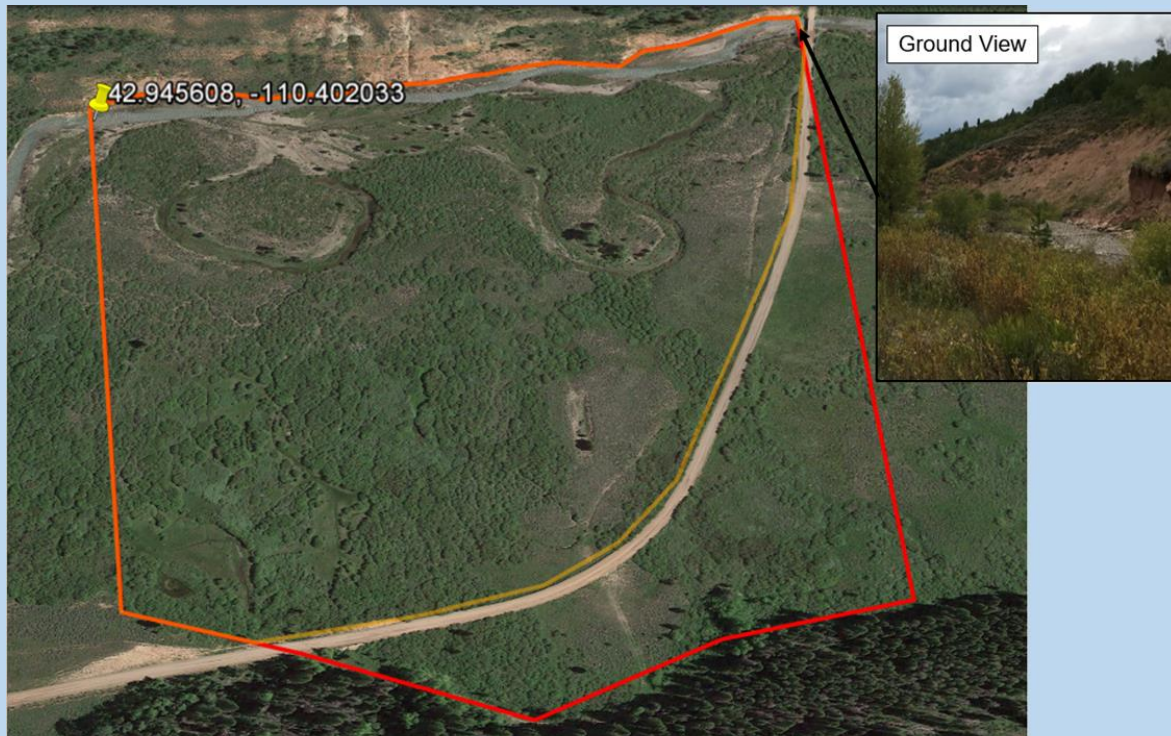
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<sup>29</sup> Google Earth or high-resolution digital imagery is available from DigitalGlobe.



**Example 11: Riparian Extent**

The stream shown below has been channelized against the edge of the valley. The image shows an example of how the riparian extent metric can be calculated by delineating the observed (yellow) and expected (red) riparian area within a project reach. The riparian area boundaries were delineated using aerial photographs and indicators of the extent were verified in the field. Review of aerial imagery included identification of any observable topographic and valley edge indicators. Existing riparian extent was delineated by also considering indicators of anthropogenic modification, in this case, the presence of a road. In this example, the observed riparian area (yellow) was 39.7 acres, the expected riparian area (red) was 48.6 acres and the O/E calculation was 81.7%.



**Expected Riparian Area:** The expected riparian area consists of the extent of the riparian corridor landward from the stream in each direction, to the extent of geomorphic and hydrologic indicators of the floodplain (Merritt et al. 2017). Typical indicators for the expected riparian extent are described below.

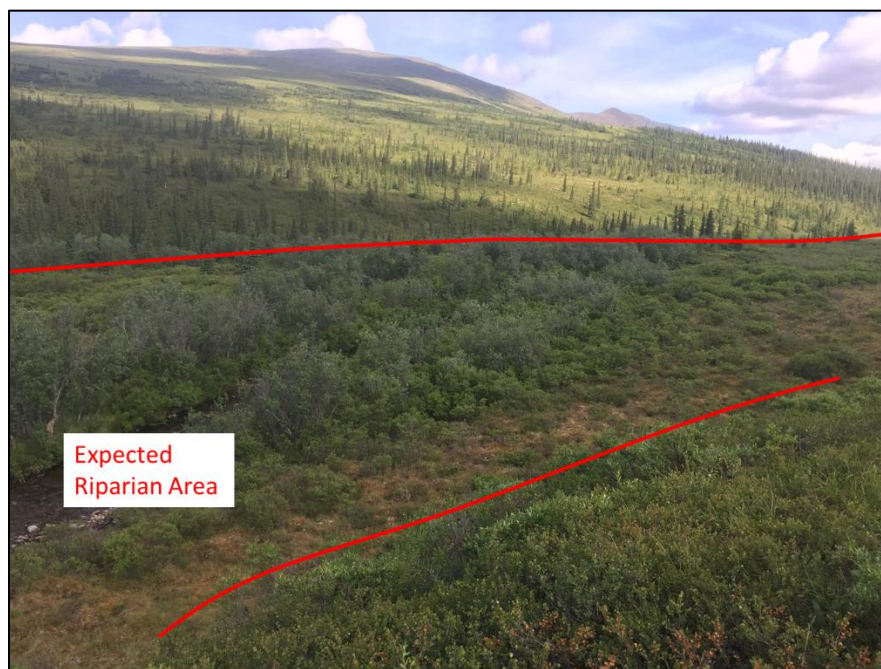
- Substrate and topographic indicators are found within the portion of the valley bottom influenced by fluvial processes under the current climatic regime. Indicators may include terracing or other breaks in slope between the bankfull and valley edge (Figure 25), fluvial deposited sediments, or a lack of upland soil formation.
- Hydrologic indicators are found where the valley bottom would be flooded at the stage of the 100-year recurrence interval.<sup>30</sup> Use published floodplain mapping, if available. Field

<sup>30</sup> The floodplain extent may be tied to recurrence intervals less than the 100-year, depending on the process domain at the project site (see Merritt et al. 2017 and Polvi et al. 2011).



indicators may include evidence of flood events (e.g., bar or other sediment deposition, debris dams).

- When this assessment is being performed in an undisturbed system (pre-impact, existing condition assessment), the biotic indicators provided below for the observed riparian area may also be applicable.



*Figure 25: Photo taken from a terrace showing topographic extent of expected riparian area.*

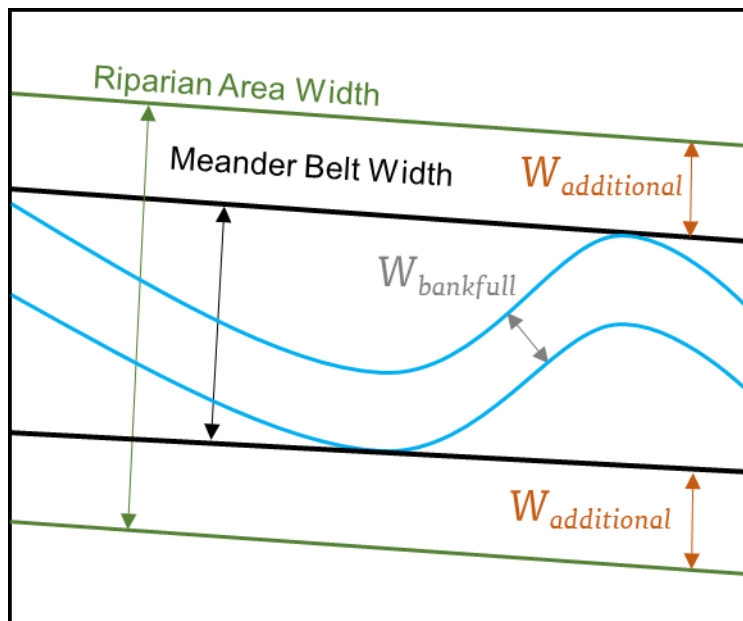
Where two streams share a valley, wildland fire, or significant anthropogenic modification of the riparian area has occurred (e.g., development, grading, incision) and aerial imagery, spatial data, and/or field indicators cannot be used to delineate the expected riparian extent, two options can be employed:

1. Historic aerial images may be used in combination with topographic, geomorphic, or burn perimeter maps to determine riparian extent prior to disturbance. Or riverine deposits may be reconstructed from geologic and soils maps and compared to current aerial images.
2. The meander width ratio (MWR) may be used to calculate expected riparian extent. The MWR is the belt width of a meandering stream in its valley divided by the bankfull width (Rosgen 2014). This option does not require the MWR to be measured but instead applies a typical MWR based on the valley type (Table 8). To determine the expected riparian area using this method, multiply the bankfull channel width of the channel by a selected MWR for the given valley type and add an additional width for outside meander bends (see equation below and Figure 26). The expected riparian area should then be multiplied by valley length to calculate expected riparian area. Valley length should be calculated along the centerline of the valley.

$$\text{Expected Riparian Area} = \text{Valley Length} * (W_{\text{Bankfull}} * \text{MWR} + 2 * W_{\text{additional}})$$

**Table 8: MWR by Valley Type adapted from Harman et al. (2012) and Rosgen (2014)**

Valley Type	MWR	Additional Width (ft) $W_{additional}$
Alluvial Valley	7	25
Confined Alluvial	3	15
Colluvial	2	10

**Figure 26: Expected Riparian Width Calculation Relying on Meander Width Ratio**

**Observed Riparian Area** – The observed riparian area is the area within the expected riparian area that is undisturbed. In other words, the portion of the expected riparian area that currently contains riparian vegetation and is free from urban, utility-related, or agricultural land uses and development.

Where this assessment is being performed in an undisturbed system (e.g., where impacts are proposed), the following guidance can assist in determining the expected and observed riparian area for the existing, pre-impact, condition using primarily biotic indicators.

- In the Alaskan Interior, vegetation adapted to fluvial influences can be helpful (certain species of willow and poplar/cottonwood, thinleaf alder (*Alnus incana*), among others), but the indicators might be a subtle change in density/cover.
- In some valleys dominated by wetland vegetation, the riparian area may contain upland species that are adjacent to the channel (e.g., riparian white spruce (*Picea glauca*) communities) where hydraulic and thermal processes keep the soils near the channel well-drained. In some situations, indicator of riparian extent could be when a non-wetland riparian area transitions to a landward wetland.

**Estimating proposed condition field values:** The field value for this metric is the percent of the expected riparian area that is currently occupied by riparian vegetation; the expected riparian area is the same for both the existing and proposed calculations. The observed value for the proposed condition can be calculated based on anticipated areas of riparian vegetation planting or riparian vegetation removal/disturbance associated with the proposed project in the expected riparian area.

### ***Vegetative Complexity***

This metric characterizes abundance and type of vegetation across three strata, which affect channel stability, floodplain roughness, and provide habitat for riparian dependent wildlife.

**Definition:** The vegetative complexity field value for the AKSQTint is a composite metric that includes visual aerial cover estimates from three layers defined by vegetation height:

- Canopy consists of woody vegetation taller than 16 feet (5m);
- Understory consists of woody and non-woody vegetation that is 1.6 to 16 feet (0.5m to 5m) in height; and
- Groundcover consists of woody and non-woody vegetation less than 1.6 feet (0.5m) tall.

Aerial cover is defined consistent with the methodology laid out in TR 1735-2 (BLM 2017) and is a visual estimate of the amount of shadow that would be cast by a particular category of vegetation if the sun were directly over the plot area. In other words, a visual estimate of vegetative cover projected down from an aerial view in each category of vegetation (canopy, understory, and groundcover).

**Method:** This metric is derived from data collection procedures in BLM (2017). Refer to the source material for complete field instructions. Riparian vegetation data collection should occur in mid-June and early September.

1. Establish and record 11 main transect locations within the representative sub-reach. Transects shall be equally spaced throughout the sub-reach.
2. Collect all data as described in Sections 8 and 8.1 of BLM (2017) within 10m by 10m plots centered on the 11 transects (A through K). A cover class rating (Table 9) is assigned for each the following:
  - a. Percent aerial cover of canopy
    - i. Large trees
    - ii. Small trees
  - b. Percent aerial cover of understory
    - i. Trees, shrubs, and saplings (woody)
    - ii. Herbaceous vegetation (non-woody)
  - c. Percent aerial cover of groundcover (<0.5m high).
    - i. Trees, shrubs, and saplings (woody)
    - ii. Herbaceous vegetation (non -woody)

**Table 9: Cover Class Ratings and Associated Proportional Cover (BLM 2017)**

Cover Class Rating	Description	Proportional Cover
0	0% – Absent	0.000
1	<10% – Sparse	0.050
2	10-40% – Moderate	0.250
3	40-75% – Heavy	0.575
4	>75% – Very heavy	0.875

3. For each vegetation plot (22 total) calculate the sum of the proportional cover values (Table 9) for the two vegetation types and three strata.
4. The field value for the SQT is the average vegetative complexity value from all of the plots calculated in Step 3. Refer to Example 12.

**Estimating proposed condition field values:** The proposed condition field value should be an estimate of vegetative complexity for conditions at the end of monitoring. Users should consider the extent of preserved vegetation, vegetation removal, and the growth rates and expected cover for planted vegetation over the monitoring period.

**Example 12: Vegetative Complexity**

For simplicity, this example shows data from two transects (A and B). Each project reach will include 11 transects (A through K) resulting in 22 plots.

Example field data from two transects showing ordinal ratings for cover classes:

Transect – Bank	Canopy (>5m)		Understory		Ground Cover	
	Large Trees	Small Trees	Woody	Non-woody	Woody	Non-woody
A – Left	1	2	3	1	4	2
A – Right	0	0	3	0	3	1
B – Left	0	4	2	0	3	3
B – Right	0	0	3	0	2	2

Proportional values and vegetative complexity calculation for each of two transects:

Transect – Bank	Canopy (>5m)		Understory		Ground Cover		Sum
	Large Trees	Small Trees	Woody	Non-woody	Woody	Non-woody	
A – Left	0.050	0.250	0.575	0.050	0.875	0.250	<b>2.050</b>
A – Right	0.000	0.000	0.575	0.000	0.575	0.050	<b>1.200</b>
B – Left	0.000	0.875	0.250	0.000	0.575	0.575	<b>2.275</b>
B – Right	0.000	0.000	0.575	0.000	0.250	0.250	<b>1.075</b>

The average of the two transects (4 plots) shown above is 1.650. The field value is the average of the sum column from all 22 plots.

**Native Cover**

**Definition:** Native species are those that score less than or equal to 70 in the Invasive Plant Ranking System. This metric characterizes the proportion of plots within the representative sub-reach that consist solely of native, or non-invasive, species.

**Method:** This metric is derived from data collection procedures outline BLM (2017). Field instructions are summarized below, refer to the source material for complete instructions. Riparian vegetation data collection should occur in mid-June and early September.

1. Record the presence or absence of non-native woody and non-native herbaceous vegetation for all layers combined within each of the 10m by 10m plots centered on the 11 transects (A through K) assessed for vegetative complexity (previous section).
  - a. For this assessment, only note the presence of invasive species, or non-native species with a score greater than 70 in the Invasive Plant Ranking System.<sup>31</sup> Note that species can be added or removed by the regulating agency on a project specific basis. Species

<sup>31</sup> <https://accs.uaa.alaska.edu/invasive-species/non-native-plants>

of particular concern for riparian areas in the Interior include: bird cherry (*Prunus padus*), birdvetch (*Vicia cracca*), and white sweetclover (*Melilotus alba*).

2. The number of plots that consist solely of native cover, where invasive cover is absent, is divided by the number of plots assessed (22) and multiplied by 100 to calculate the field value for the AKSQTint.

Note that more detailed field methods (e.g., line point intercept) may be required by the regulating agency on a project-specific basis. Field values can be generated using more detailed methods and still entered and scored in the AKSQTint condition assessments.

**Estimating proposed condition field values:** The field value for the proposed condition is an estimate of conditions at the end of monitoring or project closeout. The value can be estimated based on proposed invasive species removal and any associated monitoring and management plan (or lack thereof). Invasive species can often take over a recently disturbed site and, for restoration projects, requires active management to ensure success of planted native species. Where there is a seed source for invasive non-native species, an impacted site will likely see an increase in non-native cover unless a vegetation management plan is implemented.

## 2.10 Physicochemical Functional Category Metrics

The AKSQTint contains three function-based parameters to assess the physicochemical functional category: temperature, turbidity, and diatoms. Not all parameters will be evaluated for all projects. Refer to Section 2.5 of this manual for recommendations on when to apply each parameter and metric.

### 2.10.1 Temperature

**Definition:** Temperature in the AKSQTint characterizes the in-stream summer temperatures within a reach.

There is one metric included in the AKSQTint for the temperature parameter: the daily maximum temperature (O/E).

**Experience Requirements:** Data collection for temperature metrics should be performed by personnel with experience installing stream temperature data loggers and processing data in accordance with *Stream Temperature Data Collection Standards and Protocol for Alaska* (Mauger et al. 2014).

#### *Daily Maximum Temperature (O/E)*

**Definition:** The daily maximum temperature is the highest water temperature recorded during a given day during the sampling period (Mauger et al. 2014). The metric field value for the AKSQTint is the daily maximum temperature observed in the project reach divided by the daily maximum temperature reading in a reference reach.

This metric requires monitoring at the project reach and a reference reach. Refer to Section 2.5.1 for guidance on reference reach selection. Factors that influence temperature and should be taken into account in selecting a reference reach are documented by EPA (2014), Dunham



et al. (2005), and Mauger et al. (2014) and include but are not limited to: groundwater input, sheeting, slope, and flow.

Temperature is used in the AKSQTint to calculate a change in condition as a result of reach-scale impact and restoration activities. The primary goal of the metric field values and associated scoring is to calculate functional loss as well as lift. Functional capacity descriptions and scoring in the AKSQTint are not suitable criteria for attainment and listing, refer to 18 AAC 70.020 for further information on water quality criteria regarding temperature.

**Method:**

1. Install continuous temperature data loggers at both the project reach and reference reach following *Stream Temperature Data Collection Standards and Protocol for Alaska* (Mauger et al. 2014). Minimum standards are summarized in Table 1 of the Standards portion of Mauger et al. (2014).
  - a. For the AKSQTint, the sampling period minimum is June 1<sup>st</sup> to August 31<sup>st</sup>; minimum 91 days. It is recommended to sample for as much of the open-water season as possible.
  - b. Record data and perform any necessary maintenance throughout the sampling period. Follow all quality assurance and quality control procedures outlined in the standards and procedures of Mauger et al. (2014).
2. Determine the maximum temperature recorded within each 24-hour period and record the maximum value at both the project reach and reference reach.
3. Calculate the field value for the AKSQTint as the maximum temperature from the project reach divided by the maximum temperature at the reference reach.

**Only one season of data is required** to calculate a field value for the AKSQTint. However, as water temperature is strongly influenced by meteorological conditions, it is **recommended** that multiple years of data are collected and averaged to inform the existing condition field value.

**Estimating proposed condition field values:** The proposed condition field value should estimate/predict the expected change in the daily maximum field value resulting from the project. Practices that could impact in-stream summer temperatures include, but are not limited to, altering streamside vegetation and channel shading, groundwater connections, or summer baseflows (altered through management agreements).

## 2.10.2 Turbidity

**Definition:** Turbidity is the appearance of cloudiness or opacity of water in a stream.

There is one metric included in the AKSQTint for the turbidity parameter: the daily average turbidity (O/E).

**Experience Requirements:** Data collection for turbidity should be performed by personnel with experience calibrating and installing turbidity data loggers and processing data in accordance with *Listing Methodology for Determining Water Quality Impairments from Turbidity* (ADEC 2016).

### **Daily Average Turbidity (O/E)**

**Definition:** The daily average turbidity is the 24-hour average of hourly (or more frequent) turbidity readings (ADEC 2016). The metric field value for the AKSQTint is the maximum daily average turbidity observed in the project reach divided by the maximum daily average turbidity reading in a reference reach.

This metric requires monitoring at the project reach and a reference reach. Refer to Section 2.5.1 for guidance on reference reach selection. Factors that influence turbidity and should be taken into account in selecting a reference reach include, but are not limited to, groundwater inputs; permafrost degradation; and whether a stream is glacial, colluvial, alluvial, or experiences year-round staining from riverine wetlands. Monitoring the same water body, upstream of anthropogenic influence and in a similar geomorphic setting is preferred (ADEC 2016).

Turbidity is used in the AKSQTint to calculate a change in condition as a result of reach-scale activities. Functional capacity descriptions and scoring in the AKSQTint are not suitable criteria for use attainment and 303(d) listing, refer to ADEC (2016) for further information on water quality criteria.

#### **Method:**

1. Install continuous turbidity data loggers at the project site and reference reach. Follow all instrumentation guidance for installation and maintenance. To the extent practicable, follow the minimum data collections standards outlined for temperature loggers in *Stream Temperature Data Collection Standards and Protocol for Alaska* (Mauger et al. 2014). This includes all quality assurance and quality control, and all data storage standards in Table 1 of that report. The data logger requirements, sampling frequency, and duration are outlined below.
  - a. Turbidity data loggers must meet the requirements of EPA method 180.1 (EPA 1993) or ISO 7027.<sup>32</sup>
  - b. Deploy turbidity data loggers for as much of the open-water season as possible, but for a minimum period of three calendar months. The sampling period must be the same or similar for each year/monitoring event in the AKSQTint.
  - c. The data loggers should be placed at similar depths and relative locations (e.g., same habitat feature, proximity to the bank) at both sites. Site selection and data processing are described in Lewis and Eads (2009). The sections on deployment and site operations provide important things to consider but are stricter than what is required for this metric.<sup>33</sup>
  - d. Record the median of rapid series of turbidity measurements rather than instantaneous measurements (Lewis and Eads 2009).

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<sup>32</sup> <https://or.water.usgs.gov/grapher/fnu.html>

<sup>33</sup> This reference covers Turbidity Threshold Sampling and contains instructions for stage measurement devices, turbidity data loggers, and pumping samplers used to develop suspended sediment rating curves. This metric in the SQT only requires deployment of turbidity data loggers.

2. Calculate the daily average turbidity for each day in the sample period at both the project reach and reference reach.
3. Determine the maximum daily average value within the sampling period at both the project reach and reference reach.
4. Calculate the field value for the AKSQTint as the maximum daily average turbidity from the project reach divided by the maximum daily average turbidity at the reference reach.

**Only one season of data is required** to calculate a field value for the AKSQTint. However, as turbidity is highly variable, it is **recommended** that multiple years of data are collected and averaged to inform the existing condition field value.

**Estimating proposed condition field values:** The proposed condition field value should estimate/predict the expected change in the turbidity field value resulting from the project. Practices that could impact turbidity include, but are not limited to, reducing bank erosion, removing sources of sediment from the floodplain, or revegetating the floodplain.

### 2.10.3 Diatoms

**Definition:** Diatoms are single-celled algae with silica cell walls. They are primary producers that respond to physical and chemical impacts including nutrients, trophic status, acidification, organic pollution, and sedimentation (Rinella and Bogan 2007).

There is one metric included in the AKSQTint for this parameter and it is considered provisional in this version of the AKSQTint: Diatom Index. The Diatom Index was developed by Rinella and Bogan (2007) to assess the biological condition of streams in the Cook Inlet region of Alaska. Therefore, it is highly recommended that diatom samples be collected, and an index calculated at both the project site and a reference reach.

**Experience Requirements:** Data collection and processing should be performed by professionals with experience collecting algal samples in accordance with EPA (2009) or Barbour et al. (1999). Due to known issues with consistency in taxonomy among different labs, the same lab (either commercial or academic) should be used to process and identify all samples.

#### *Diatom Index*

**Definition:** The Diatom Index is a regionally calibrated diatom-based multi-metric index for the Cook Inlet region of Alaska. It is currently being tested in the Alaskan Interior.

**Method:** Methods for collecting and processing diatom data are outlined EPA (2009) and summarized in Rinella and Bogan (2007).

Diatom Index scores are calculated following the instructions provided in Rinella and Bogan (2007). The steps for evaluating new streams are described below:

1. Calculate the individual metric scores using Table 5 in Rinella and Bogan (2007). Setting any calculated values that are greater than 100, to a value of 100 and any calculated values that are less than 0, to a value of 0.

2. Calculate the Diatom Index score by averaging the metric scores calculated in Step 1.
3. The Diatom Index score calculated in Step 2 is entered as the field value for the AKSQTint.

**Only one sample is required** to characterize the existing condition. However, it is recommended that multiple samples be collected over multiple years if feasible to capture intra- and inter-annual variability. Refer to the monitoring section in Section 3.4 for more detail.

**Estimating proposed condition field values:** The proposed condition field value should estimate/predict the expected change in the Diatom Index score resulting from the project. Practices that could impact the Diatom Index score include, but are not limited to, altering nutrient loads entering the stream channel from the lateral drainage area (through management agreements or buffer planting). Also, decreasing sedimentation from streambank erosion could improve the Diatom Index score.

## 2.11 Biology Functional Category Metrics

The function-based parameters included in the AKSQTint for the biology functional category are macroinvertebrates and fish. Refer to Section 2.5 of this manual for recommendations on when to apply each parameter and metric.

### 2.11.1 Macroinvertebrates

**Definition:** Benthic macroinvertebrates, also called aquatic macroinvertebrates, are an integral part of the food web and are commonly used as indicators of stream ecosystem condition.

There is one metric for this parameter, a multi-metric bioassessment index (MMI) called the Alaskan Interior MMI. The MMI was developed and tested using macroinvertebrate and environmental data from 200 streams in the Alaskan Interior.

**Experience Requirements:** Field values for macroinvertebrate metrics should be collected by professionals with training and experience sampling and preserving samples in accordance with BLM Technical Reference 1735-2, *AIM National Aquatic Monitoring Framework: Field Protocol for Wadeable Lotic Systems* (BLM 2017). Samples require laboratory identification and enumeration at a professional taxonomic laboratory. Due to known issues with consistency in taxonomy among different labs, it is recommended that a lab that is involved with the BLM AIM program or the EPA NRSA program be contracted for this work. A list of these labs is provided in Appendix D. At this time, calculation of the Alaskan Interior MMI score requires the assistance of the index developers at the BLM National Aquatic Monitoring Center.

#### *Alaskan Interior MMI*

**Definition:** The Alaskan Interior MMI is a regionally calibrated macroinvertebrate-based multi-metric index for the eastern portion of the Alaskan Interior.

**Method:** Methods for collecting and processing macroinvertebrate samples are outlined in BLM Technical Reference 1735-2, *AIM National Aquatic Monitoring Framework: Field Protocol for Wadeable Lotic Systems* (BLM 2017). Macroinvertebrate samples should be sent to a

professional taxonomy laboratory (Appendix D) for enumeration and identification to the lowest practicable taxonomic level.

Alaskan Interior MMI scores are calculated following the instructions provided in Armstrong *et al.* (2021). Note that at this time, calculation of Alaskan Interior MMI scores for new sites requires the assistance of the index developers at the BLM National Aquatic Monitoring Center. The steps for evaluating new streams are described below:

1. Raw macroinvertebrate sample taxa are converted to Operational Taxonomic Units (OTU) as defined by Armstrong *et al.* (2021).
2. Samples are randomly resampled to a fixed count of 350 individuals (unless sample has fewer than 350 individuals).
3. Raw values for 5 metrics (dominant taxon abundance, non-insect abundance, collector-filterer abundance, number of collector-filterer taxa, number of shredder taxa) are calculated.
4. The catchment for the sampled reach is delineated and values for the required environmental predictor variables are calculated using ArcGIS as described in Armstrong *et al.* (2021).
5. The random forest models described in Armstrong *et al.* (2021) are used to calculate predicted values for the first 4 metrics listed above. Residuals (predicted-observed) are calculated and used as metric values for these 4 metrics, raw values are used for number of shredder taxa.
6. Metric values are rescaled as described in Armstrong *et al.* (2021) and the average value is used as the Alaskan Interior MMI score.
7. The Alaskan Interior MMI score calculated in Step 6 is entered as the field value for the AKSQTint.

**Only one sample is required** to characterize the existing condition. However, it is **recommended** that multiple samples be collected over multiple years if feasible to capture intra- and inter-annual variability. Refer to the monitoring section in Section 3.4 for more detail.

**Estimating proposed condition field values:** The proposed condition field value should estimate/predict the expected change in Alaskan Interior MMI score resulting from the project. Practices that could impact macroinvertebrate communities include, but are not limited to, altering in-stream water quality (refer to Section 2.10), presence, extent and quality of macroinvertebrate habitat, and landscape and aquatic connectivity.

### 2.11.2 Fish

**Definition:** Fish are an integral part of many functioning stream ecosystems and are an important management priority within Alaska.

Three metrics for fish are included in the AKSQTint: fish species richness (% expected), relative abundance (O/E), and species biomass (O/E). Sampling methods for all metrics are the same

and are presented first, followed by individual sections that provide detail on data analysis and field value calculations.

**Experience Requirements:** Users should have experience performing standard fish sampling techniques to capture the full array of potential species at a site. Electrofishing, species identification, and population estimates should be performed by trained fisheries biologists or aquatic ecologists. Fisheries biologists or aquatic ecologists performing species identification should be able to identify 100% of the fish species present.

**Note:** An Aquatic Resource Permit from the ADF&G is required to collect fish samples.<sup>34</sup>

Project specific consultation with an area fishery biologist from ADF&G can provide local information on potential limiting factors to improving fish communities based on the location of the project reach and the seasonal distribution of salmonid species in the basin.

### ***Fish Sampling***

A paired reach-based sampling design which requires sampling at both the project reach and a reference reach is used for calculating fish metric field values. The reference reach must represent reference standard conditions for the project reach with respect to the fish species assemblage, abundance, and biomass (refer to Section 2.5.1). The reference reach for the fish parameters should be geographically proximate to the project reach but outside the influence of the project actions. Relevant processes to consider in reference reach selection for this parameter include anadromy and connectivity to larger order streams. Wadeable stream reaches within drainage networks that include anadromy or have close proximity to larger order streams may have increased fish abundance compared to reaches of similar order streams located further away from larger order streams.

#### **Method:**

A minimum of two sampling events (Bonar et al. 2009) at each reach (i.e., 4 total events for a reach pair) will be conducted annually for two years. This is a total of 8 sampling events, 4 at each reach (refer to Example 13). All detailed fish surveys should be conducted according to the following guidance:

- A sampling methodology acceptable to ADF&G is required, such as multi-pass depletion sampling. Whichever sampling methods are used to assess fish populations at the start of the project must be continued throughout all subsequent monitoring events.
- To verify fish identification, users should collect and preserve voucher specimens of fish species not readily identified in the field.
- Sampled fish should be measured (e.g., fork length) and weighed. In instances where length/weight relationships have been established for a particular species, fish lengths can be used to derive estimated weight for biomass computations.

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<sup>34</sup> [http://www.adfg.alaska.gov/index.cfm?adfg=otherlicense.aquatic\\_resource](http://www.adfg.alaska.gov/index.cfm?adfg=otherlicense.aquatic_resource)



- Because of inter- and intra-annual variability in native fish communities, at least **four sampling events are required** to inform a single field value for the AKSQTint: two consecutive years each with two sampling events that occur at least 45 days apart.
- Paired sampling of the project and reference reaches must occur within less than 7 days of one another.
- A site-specific sampling plan may be needed, particularly in anadromous streams.
- **Sampling events should avoid spawning seasons.**

#### Example 13: Fish Sampling Data

Multi-pass depletion sampling was performed at a project reach and a nearby reference reach. Both the project reach and reference reach are not anadromous. Fish counts from sampling are provided below and the weight/length of each fish was also recorded in the field for biomass estimates.

Project Reach – Stream has been straightened and channelized and the reach is one long homogeneous riffle.

Species	6/8/2018	7/26/2018	6/16/2019	8/3/2019
Arctic grayling ( <i>Thymallus arcticus</i> )	0	0	0	1
Slimy Sculpin ( <i>Cottus cognatus</i> )	0	2	0	2
<b>Total Count</b>	<b>0</b>	<b>2</b>	<b>0</b>	<b>3</b>

Reference Reach – Neighboring stream in similar setting that has not been disturbed.

Species	6/8/2018	7/26/2018	6/16/2019	8/3/2019
Arctic grayling ( <i>Thymallus arcticus</i> )	5	10	8	12
Dolly Varden ( <i>Salvelinus malma</i> )	3	2	7	4
Slimy Sculpin ( <i>Cottus cognatus</i> )	11	12	11	15
<b>Total Count</b>	<b>19</b>	<b>24</b>	<b>26</b>	<b>31</b>

These data are used in the following examples to demonstrate calculation of field values for the three fish metrics.

Post-mining reclamation of the project reach will be completed in 2021 and monitoring is planned for the summers of 2022/2023, 2026/2027, and 2031/2032 to document restoration of the fish community.

### ***Fish Species Richness (% expected)***

**Definition:** This metric documents the diversity of the native fish community by comparing the number of native species observed in the reach to the number of native species expected in the absence of anthropogenic stressors. The number of native fish species in a reach is commonly referred to as the assemblage or species richness.

The field value entered into the AKSQTint is a percent calculated using the following equation:

$$\text{Field Value} = \frac{\text{Observed Fish Species Richness}}{\text{Expected Fish Species Richness}} \times 100$$

#### **Method:**

1. Perform sampling at both the project reach and a reference reach as described in the previous section.
2. Determine the expected native fish assemblage.<sup>35</sup> The “expected” community consists of the fish that should be naturally present, in the absence of anthropogenic influence. Refer to the Alaska Freshwater Fish Inventory<sup>36</sup>, the Anadromous Waters Catalog<sup>37</sup>, and annual reports from aquatic resource sampling permits<sup>38</sup> for a preliminary estimate of the expected native fish assemblage at a project site, at the reference reach, and within adjacent areas. The user should include all species identified at the reference reach and coordinate with an area fishery biologist at ADF&G to further refine the expected species assemblage for the project site.

Take residency time and sampling plan into account when developing the native species assemblage. For example, summer sampling would not reasonably expect to identify chum salmon due to short residency in freshwater after emergence.

3. Determine the observed native fish assemblage from the sampling events. A species is counted as present if it was observed during **at least one of the four sampling events**.
  - a. Any native species found at the project site or the reference reach that are not included on the expected native fish assemblage will need to be added to the expected native fish assemblage. This will involve updating previously reported field values.
4. The field value for the AKSQTint is calculated as the percent of species from the expected native fish assemblage that were observed during the four sampling events. Example 14 provides an example for a non-anadromous project reach.

**Estimating proposed condition field values:** The proposed condition field value should estimate/predict the number of species anticipated to be present following the proposed project. Consultation with an area fishery biologist at ADF&G to determine the expected species

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<sup>35</sup> <https://www.adfg.alaska.gov/index.cfm?adfg=animals.listfish>

<sup>36</sup> <http://www.adfg.alaska.gov/index.cfm?adfg=ffinventory.main>

<sup>37</sup> <https://www.adfg.alaska.gov/sf/SARR/AWC/>

<sup>38</sup> [http://www.adfg.alaska.gov/index.cfm?adfg=otherlicense.aquatic\\_reports](http://www.adfg.alaska.gov/index.cfm?adfg=otherlicense.aquatic_reports)

assemblage will inform the anthropogenic causes of impairment and whether the proposed actions could alter the observed assemblage.

#### Example 14: Fish Species Richness

Using the data from Example 13, the number of species observed in the project reach and reference reach are summarized below. The native fish assemblages for both reaches were expected to include burbot due to the proximity of the Chena River to these reaches, but this species was not found. Discussions with fisheries biologists indicate that burbot would be expected in these reaches but disturbance outside the project area is preventing them from being present.

Sampling Event	Observed Richness			
	6/8/2018	7/26/2018	6/16/2019	8/3/2019
Project Reach	0	1	0	2
Reference Reach	3	3	3	3

The expected assemblage for the project reach in the absence of anthropogenic disturbance consists of four (4) species: slimy sculpin (*Cottus cognatus*), Arctic grayling (*Thymallus arcticus*), Dolly Varden (*Salvelinus malma*), and burbot (*Lota lota*). The observed assemblage in the project reach consisted of only two (2) species. The existing condition field value is therefore 50%. Since the reach-scale restoration will not address the stressors keeping burbot from being present but is expected to address the stressors keeping Arctic grayling out of the project reach, the proposed condition field value is 75%.

Post-mining reclamation of the project reach will be completed in 2021 and monitoring is planned for the summers of 2022/2023, 2026/2027, and 2031/2032 to document restoration of the fish community. Each of the three sampling events are independent of one another. Example data and field values are provided below.

Sampling Event	# Species Observed in Project Reach		
	2022/2023	2026/2027	2031/2032
#1	2	2	3
#2	2	3	3
#1	3	3	3
#2	2	2	3
<b>Observed Richness</b>	<b>2</b>	<b>3</b>	<b>3</b>
<b>Expected Richness</b>	<b>4</b>	<b>4</b>	<b>4</b>
<b>Field Value</b>	<b>50%</b>	<b>75%</b>	<b>75%</b>

#### Relative Abundance (O/E)

**Definition:** This metric compares the relative abundance catch per unit effort (CPUE), measured within the project reach (Observed; O) to the CPUE measured at a **reference reach** (Expected; E). When comparing the project reach to the reference reach, it is critical that effort be normalized to the extent practicable. For example, when electrofishing, a single pass could

be considered one effort. If triple pass depletion sampling is used, the total number of fish sampled would be divided by three to determine the CPUE for a particular sampling event.

**Method:**

1. Perform sampling at both the project reach and a reference reach as described in the previous section.
2. Calculate the average CPUE for each calendar year at the reference reach. This is the expected CPUE in the observed over expected ratio.
3. Calculate the average CPUE for each calendar year at the project site. This is the observed CPUE in the observed over expected ratio.
4. Calculate the O/E ratio for each calendar year by dividing the results of Step 3 by the results of Step 2.
5. Calculate the field value by averaging the results of Step 4. Table 10 shows an example field value calculation using Y1 to identify the average biomass from year 1, Y2 is the average biomass from year 2.

**Table 10: Example field value calculations for relative abundance using electrofishing methods with 3 passes (i.e., 3 units of effort) per reach for each sampling event.**

	Y1 = 2018			Y2 = 2019		
	6/8/2018	7/26/2018	Average	6/16/2019	8/3/2019	Average
Project Reach	0.00	0.67	<b>0.34</b>	0.00	1.00	<b>0.50</b>
Reference Reach	6.33	8.00	<b>7.17</b>	8.67	10.33	<b>9.5</b>
O/E	-		<b>0.047</b>	-		<b>0.053</b>
Field Value	(0.047 + 0.053) / 2 = <b>0.05</b>					

**Estimating proposed condition field values:** The proposed condition field value should estimate/predict the change in CPUE likely to occur following the project.

**Species Biomass (O/E)**

**Definition:** This metric compares the species biomass measured within the project reach (Observed; O) to the biomass measured at a **reference reach** (Expected; E). This metric is only appropriate for sites that would be expected to include salmonid species.

**Method:**

1. Perform sampling at both the project reach and a reference reach as described in the previous section.
2. Calculate the average biomass for each calendar year at the reference reach. This is the expected biomass in the observed over expected ratio.
3. Calculate the average biomass for each calendar year at the project site. This is the observed biomass in the observed over expected ratio.

4. Calculate the O/E ratio for each calendar year by dividing the results of Step 3 by the results of Step 2.
5. Calculate the field value by averaging the results of Step 4. Table 11 shows an example field value calculation using Y1 to identify the average biomass from year 1, Y2 is the average biomass from year 2.

**Table 11: Example field value calculations for salmonid species biomass in grams.**

	Y1 = 2018			Y2 = 2019		
	6/8/2018	7/26/2018	Average	6/16/2019	8/3/2019	Average
Project Reach	0.00	0.00	<b>0.00</b>	0.00	13.00	<b>6.50</b>
Reference Reach	117.50	305.00	<b>211.25</b>	226.50	226.00	<b>226.25</b>
O/E	-		<b>0.00</b>	-		<b>0.029</b>
Field Value	(0.00 + 0.029) / 2 = <b>0.015</b>					

**Estimating proposed condition field values:** The proposed condition field value should estimate/predict the change in biomass likely to occur following the project.

## Chapter 3. Applying the AKSQTint for Stream Restoration

This chapter outlines the process and concepts that should be considered for stream restoration projects, including reclamation and those providing mitigation under CWA 404 (i.e., mitigation banks, in-lieu fee projects, or on-site/off-site permittee responsible mitigation projects). The sections of the SQT workbook that should be completed for restoration and mitigation projects are summarized in Table 12. See Section 1.2.4 for information on how the SQT workbook calculates functional lift.

**Table 12: SQT Worksheets Used for Restoration Projects**

Worksheets	Relevant Sections
Project Assessment (Section 1.2.1)	<ul style="list-style-type: none"> <li>• Programmatic Goals</li> <li>• Reach Description</li> <li>• Restoration Approach</li> <li>• Aerial Photograph of Project Reach</li> </ul>
Catchment Assessment (Section 2.3)	<ul style="list-style-type: none"> <li>• Complete entire form</li> <li>• Determine restoration potential</li> </ul>
Quantification Tool (Section 1.2.4)	<ul style="list-style-type: none"> <li>• Site Information and Reference Selection</li> <li>• Existing Condition field values*</li> <li>• Proposed Condition field values*</li> </ul>
Monitoring Data (Section 1.2.5)	<ul style="list-style-type: none"> <li>• As-Built Condition field values*</li> <li>• Field values for up to 10 monitoring events**</li> </ul>
Data Summary	No data entry in this worksheet
Reference Curves	No data entry in this worksheet
* Guidance on parameter selection is provided in Section 2.5 and detailed instructions for collecting and analyzing field values for all metrics are provided in Chapter 2.	
** Guidance on collecting and entering data for monitoring events is provided in Section 3.4.	

### 3.1 Site Selection

The AKSQTint can be used to assist with selecting or ranking the priority of a potential stream restoration site. While there are many other elements to include in a thorough site-selection process (ELI 2016; Starr and Harman 2016), this section only illustrates the role of the AKSQTint.

In the SQT workbook, functional lift is estimated from the difference in pre- and post-project condition scores, expressed as an overall change in functional feet. Therefore, if the user is deciding between multiple sites, the SQT workbooks can be used to rank sites based on the amount of functional lift available. If there are time or budget constraints, the user may want to evaluate potential mitigation or restoration project sites using rapid methods where available (see Chapter 2 and Appendix A). At this stage, a user will likely have to estimate post-project condition scores using best professional judgement. The user could model a variety of design approaches to see how much lift is reasonable for each parameter. While evaluating different



sites, it is generally recommended to select a mitigation site that can achieve the following post-project condition scores:

1. An index score of 0.70 or higher for floodplain connectivity, flow dynamics, bed form diversity, and lateral migration; and
2. An index score of 0.60 or higher for riparian vegetation (recognizing that riparian vegetation may take multiple years to reach full potential and therefore may not reach the functioning range of 0.70 or higher).

### 3.2 Restoration Potential

Restoration potential is defined as the highest level of restoration that can be achieved based on contributing catchment stressors and condition, reach-scale constraints, the results of the reach-scale function-based assessment, and an assessment of previous and future responses to disturbances (e.g., channel evolution). Restoration potential is determined using a stepwise process (Section 3.2.1). Components important to determining restoration potential are described in detail in the following sections. Restoration potential definitions include:

- Full Restoration Potential – The project reach has the potential to *restore functions within all five Pyramid levels back to a reference standard condition*. Reference standard condition reflects the least disturbed aquatic resources in a given class of resource and exhibits the highest levels of functions exhibited by that class (Federal Register 73:70 (April 10, 2008) p. 19624). Refer to Table 1 in Section 1.2.
- Partial Restoration Potential – The project reach has the potential to *restore some functions to a condition better than pre-project or baseline conditions*. However, the project reach does not have the potential to restore to functions within all five Pyramid levels back to reference standard condition.

Partial restoration is the most common potential for restoration projects. Typically, some catchment stressors or reach-scale constraints prevent the site from reaching full restoration potential.

For example, watershed processes and reach-scale constraints influencing a project site are often functioning sufficiently enough that some functions/conditions, such as floodplain connectivity, channel stability (dynamic equilibrium) and in-stream habitat, for example, could be restored, but these same constraints are preventing the successful restoration of the physicochemical and biological functions. Improvements in all Pyramid levels may be observed, but these improvements may not reflect a fully functioning reference standard condition.

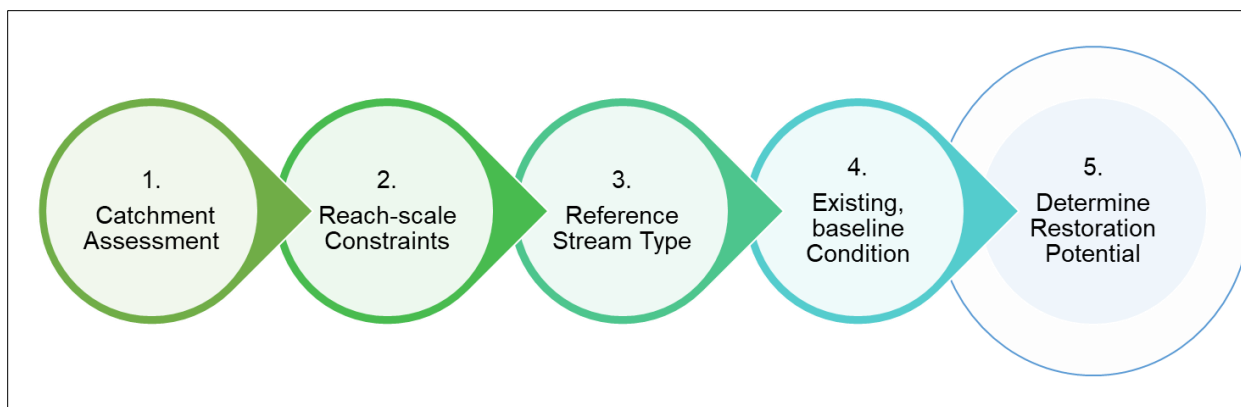
There are likely situations where even partial restoration is not possible due to the severity of the catchment stressors and project constraints. For example, flow alteration (stressor) may modify the hydrologic and sediment transport processes within a catchment, and these factors may be outside of the control of the practitioner. Land use constraints like sewer lines and roads may artificially constrain the project limits. Some stressors and constraints limit restoration potential to such a degree that the site is not appropriate for restoration activities. If the underlying processes do not have the potential to support at least partial restoration, the site may not be suitable for restoration.

The SQT workbook requires the user to determine the restoration potential for each project reach. Restoration potential can be used for a variety of applications. A few are listed below:

- Clear communication of project expectations – Clearly communicating the goals of a stream restoration project, and the expectations in terms of what is being restored is vital for the practice of stream restoration. Text can be included in a restoration/mitigation plan to clearly communicate project expectations. This will assist future readers and researchers who want to evaluate the project's success in restoring stream functions.
- Development of function-based goals – Restoration potential can be used to inform realistic project goals, which are qualified by catchment- and reach-scale conditions. The development of function-based goals and objectives is described in more detail in Section 3.2.2.
- Parameter and metric selection – Function-based goals and objectives can be reflected in parameter and metric selection in the SQT workbook. For example, a reach with full restoration potential must monitor physicochemical and biology parameters. When a reach has partial restoration potential, physicochemical and biology parameters may be monitored if lift is expected, however users and regulatory agencies may not want to monitor physicochemical and biology functions due to the potential for further watershed impairment.
- Assisting with alternatives analysis – The process of evaluating restoration potential can help develop design alternatives by raising questions about the size and scope of the project and the removal of reach-scale constraints and catchment stressors. For example, if the project size is increased and constraints are eliminated, the restoration potential may increase.
- Assisting with final site selection – Stream restoration project sites are selected for a wide variety of reasons, primarily depending on the funding or program driver. However, knowing the restoration potential and comparing it to project goals (including funding goals) can assist in site-selection.

### **3.2.1 Stepwise Approach to Determining Restoration Potential**

Restoration potential is determined for each project reach (Section 2.1) individually following the steps outlined below (Figure 27) and is then entered in the Catchment Assessment worksheet. Results are automatically copied to the Site Information and Reference Selection section of the Quantification Tool worksheet.



*Figure 27: Stepwise approach to determining restoration potential*

1. Complete the Catchment Assessment worksheet (Section 1.2.2 and 2.3). Review the scores for each category to determine if an identified stressor can be overcome by proposed activities or whether it will limit restoration potential in the project reach. A stressor that prohibits even limited partial restoration may constitute a “deal breaker”, meaning the reach is not a good candidate for stream restoration activities unless catchment-scale stressors can be improved.
  - a. Compare the reach size to the catchment size (length and/or area). Can the scale and type of restoration overcome the catchment stressors? At the reach scale, users should consider several factors, including the scale of the restoration project in relation to the watershed. For small catchments where the length or area of the restoration project is large compared to the total stream length or catchment area, reach-scale activities may be able to overcome the stressors and perturbations.
2. Identify reach-scale human-caused constraints and how they could limit restoration potential. Constraints are human-caused conditions, structures, and land uses that inhibit restoration activities at the reach scale and are outside the user’s control. A constraint is different than a stressor, which occurs at the catchment-scale outside of the project reach. In some cases, a stressor can be considered a constraint if it is located within the reach and will not be removed as part of the restoration plan. Constraints can negatively affect processes needed to support full restoration potential (and in extreme cases can even limit partial restoration).

Common constraints include land uses within the floodplain or valley bottom that minimize stream-corridor width (e.g., roads, utility easements, levees/berms, etc.) and existing dams or culverts that function as migration barriers for fish and prevent streambed elevation changes during design.

Note that natural conditions are not constraints. For example, while hillslopes constrain the lateral extent of meandering streams, that is not a constraint, as defined here. Hillslopes are a natural condition of the catchment. The presence of bedrock can limit changes to bed elevation and even prevent some aquatic species from migrating upstream. However, these are natural conditions that create habitat diversity. They are not considered constraints in this methodology and would therefore not limit the restoration potential.

3. Determine reference stream type. Reference stream type is entered in the Project Assessment worksheet and is the restoration target at the end of monitoring (e.g., project closeout). Reference stream type represents the stream type that should occur in a specific landscape setting given the current hydrogeomorphic watershed- and reach-scale processes.  
Selecting the reference stream type is a qualitative process and therefore requires considerable experience in fluvial geomorphology by the user.
  - a. Characterize the current condition of the stream and evaluate the process drivers (Castro and Thorne 2019). Using the Stream Evolution Triangle (SET) and Figures 6a and 6b from Castro and Thorne (2019), determine the typical Rosgen stream type(s) that might be expected given the process drivers. Note that the existing stream type may be different than the reference stream type identified.
  - b. Determine the current and future potential Stream Evolution Model (SEM), if applicable (Cluer and Thorne 2014) and Rosgen Channel Succession Scenario (Rosgen 2006). Is the stream trending towards greater or lesser functionality? What is the realistic final SEM stage and Rosgen stream type as compared to the previously undisturbed SEM Stage or stream type?
  - c. Historic, geomorphic, and stratigraphic evidence can be used in addition to the tools noted above to determine reference stream type. Information from a reference reach (Section 2.5.1) and the design process (e.g., watershed hydrology, sediment transport, or anthropogenic constraints) can also be used to inform reference stream type.
  - d. The final result is a Rosgen stream type that will be used in the SQT as a reference stream type. The most common results are an E, C, B, or Bc. Provide a narrative to justify selection of the reference stream type in the Project Assessment worksheet.

To determine reference stream type, users should have experience and knowledge about channel evolution and the Rosgen Stream Classification system. The AKSQTint relies on the Rosgen stream type classifications (Rosgen 1996) to determine reference stream type. Stream type classifications and basic fluvial landscapes in which the different stream types typically occur are described in detail in *Part 654 Stream Restoration Design National Engineering Handbook* (NRCS 2007). **The AKSQTint does not require Natural Channel Design restoration approaches.**

The SEM (Cluer and Thorne 2014), SET (Castro and Thorne 2019), and Rosgen Channel Succession Stages (Rosgen 2006) are not described in detail in this manual and users should consult the source material in applying these methods. The SEM provides more detail for systems that historically existed as stream/wetland complexes or anastomosed systems ( $D_A$  stream type). These systems are classified as response systems, typically in low gradient alluvial valleys.

4. Use the Quantification Tool worksheet to determine the baseline condition of the reach. The Quantification Tool worksheet will characterize existing functional capacity by parameter and functional category.
5. Based on Steps 1-4, describe the restoration potential as Full or Partial. Explain the reasons for your selection in the Restoration Approach section of the Project Assessment worksheet.

Identify which parameters/functions could be restored to a reference standard and which may not.

- a. The restoration potential of the project reach is recorded on the Catchment Assessment worksheet. Results are also automatically populated in the Site Information and Reference Selection Section of the Quantification Tool worksheet.

### 3.2.2 Function-Based Design Goals and Objectives

After the restoration potential has been determined, users should develop function-based goals and objectives. This information is also entered into the SQT workbook on the Project Assessment worksheet. Guidance on developing function-based goals and objectives is adapted from Harman et al. (2012).

Design goals are statements about *why* the project is needed at the specific project site and outline a general intention for the restoration project. These goals communicate the reasons behind the project's development. Design objectives explain *how* the project will be completed. Objectives are specific, tangible, and can be validated with monitoring and performance standards. Objectives, in combination with the stated goals, describe what the user will do to address the functional impairment. Typically, objectives will explain how key function-based parameters like floodplain connectivity, bed form diversity, lateral migration, and riparian vegetation will be changed to meet the goals. Design goals and objectives can be used to inform parameter selection within the SQT workbook (see Example 15).

The design goals should be cross referenced with the restoration potential of the project site to ensure that the goals do not exceed the restoration potential. For example, increasing fish species richness to a reference standard is not feasible if the restoration potential is "partial" due to limitations identified in the catchment assessment. In this example, the design goal could be revised to restore physical habitat for native species, a restoration goal that matches the partial restoration potential result. If fish populations in the project reach are to be monitored, increasing the species richness could be possible even with partial restoration potential; however, returning species richness to reference standard would not be expected or possible. If catchment-level improvements are implemented to address the stressors, full restoration could be possible. This outcome would require reach-scale *and* catchment-scale restoration efforts.

### **Example 15: Project with Partial Restoration Potential**

Partial Restoration Potential: The catchment draining to the project is mostly undisturbed forest but contains multiple mining sites along the project stream. The overall catchment health is fair and biological improvements are limited by high sediment supply.

Goals: Improve aquatic habitat for native fish communities.

Objectives: Re-plant riparian vegetation to stabilize banks, reconstruct portions of channel to improve bed form diversity (habitat).

Possible Parameter List:

Required:

- Reach Runoff
- Floodplain Connectivity
- Flow Dynamics
- Lateral Migration
- Bed Form Diversity
- Riparian Vegetation

Additional optional:

- Turbidity
- Diatoms
- Macroinvertebrates
- Fish

Monitoring is included for metrics within all categories because the project is expected to show some improvement. However, the project is not expected to restore diatoms, macroinvertebrates, and fish parameters to a reference standard.

## **3.3 Passive Versus Active Restoration Approach Examples**

The SQT workbook evaluates the functional lift of restoration activities through changes in function-based parameter scores, not by the scale of restoration activities, e.g., the amount of heavy equipment used in a project or the number of in-stream structures installed. Therefore, the SQT workbook can evaluate lift across a range of restoration approaches that require varying amounts of effort.

Hypothetical examples of three unique restoration approaches and the potential lift that can be captured using the SQT workbook are detailed below. The three example approaches include: Passive, Moderately Active, and Active. Active restoration approaches typically include significant earthwork (e.g., Priority 1 or 2) and more passive approaches typically avoid heavy machinery and may include management actions (e.g., re-routing a trail or fisherman exclusion). All three examples evaluate the following parameters:

- |                           |                       |
|---------------------------|-----------------------|
| • Reach Runoff            | • Bed Form Diversity  |
| • Floodplain Connectivity | • Riparian Vegetation |
| • Flow Dynamics           | • Diatoms             |
| • Large Woody Debris      | • Macroinvertebrates  |
| • Lateral Migration       | • Fish                |



To illustrate the benefit of monitoring physicochemical and biological condition,  $\Delta FF$  is reported at the end of this section for two monitoring scenarios, where 1) Hydrology, Hydraulics and Geomorphology are monitored, and 2) all functional categories are monitored. Thus, it was assumed that all projects could show modest improvements in diatoms, macroinvertebrates, and fish parameters.<sup>39</sup>

### **Passive Restoration Approach:**

In this hypothetical example, 1,000 linear feet of stream is flowing through forest. An existing conditions assessment showed that the stream had not been channelized in the past and meanders within a confined alluvial valley. The existing stream is a Rosgen C stream type with a single-thread sinuous channel. Due to the meanders and corresponding lateral-scour pools, bed form diversity was characterized as functioning, despite the absence of in-stream large woody debris. However, fishermen have full access to the stream so most riparian vegetation has been removed by trampling, which has led to moderate erosion on several outside meander bends. Erosion is also evident where fishermen have concentrated at convenient stream crossings. Channel widening is likely to continue so long as fishermen have access to the stream. Bank heights are low, and energy continues to be dissipated by spreading flood waters across the floodplain.

Due to upstream urban land use practices, the project received a partial restoration potential determination. The stream will likely stay a Rosgen C type but could evolve into an E if biotic interaction increases substantially and erosion resistance increases moderately. The mitigation approach is to remove intensive trampling pressure by fencing out the fishermen and re-planting the riparian area, removing concentrated flow at previous crossing locations. This passive approach is feasible because reach runoff, floodplain connectivity, flow dynamics, and bed form diversity are already within the reference standard range of condition (it often takes significant channel modification to fix these parameters). The removal of concentrated flow points and a newly planted riparian area will improve lateral migration and support limited improvement to physicochemical and biology functions within the mitigation monitoring period of 5 years (Figure 28). In this example, monitoring of diatoms and macroinvertebrate metrics revealed a slight increase in scores, however, condition scores remained in the functioning at risk range..

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<sup>39</sup> Without evaluating the physicochemical and biological parameters, the maximum overall score in the AKSQTint will be 0.60. Selecting and assessing parameters in both functional categories will increase the maximum overall score to 1.00 in the AKSQTint and will increase the amount of functional feet generated.

FUNCTION BASED PARAMETERS SUMMARY			
Functional Category	Function-Based Parameters	Existing Parameter	Proposed Parameter
Hydrology	Catchment Hydrology		
	Reach Runoff	0.35	0.65
Hydraulics	Floodplain Connectivity	0.82	0.82
	Flow Dynamics	0.85	0.85
Geomorphology	Large Woody Debris	0.33	0.33
	Lateral Migration	0.60	0.80
	Bed Material Characterization		
	Bed Form Diversity	0.79	0.79
	Riparian Vegetation	0.55	0.87
Physicochemical	Temperature		
	Turbidity		
	Diatoms	0.52	0.56
Biology	Macroinvertebrates	0.54	0.59
	Fish	0.78	0.78

*Figure 28: Passive Restoration Approach SQT workbook Example. Red equals not-functioning, yellow equals functioning-at-risk, and green equals functioning.*

### Moderate Restoration Approach:

In this hypothetical example, the stream reach is in a similar forested setting as the passive example with one major change—the stream reach has been channelized and is currently 800 linear feet in length. Although slope and stream power have increased due to channelization, the presence of underlying bedrock has prevented incision. However, the removal of meander bends and large wood have prevented pool-forming processes. Thus, bed form diversity is not-functioning compared to reference standard. The riparian vegetation has been substantially trampled, which has led to moderate bank erosion; however, floodplain connectivity has been largely maintained. In this scenario, the existing stream channel is a Rosgen Cb type. The channel will likely stay a Cb because bedrock is preventing incision.

The mitigation approach involves fencing out the fishermen, planting riparian vegetation, removing concentrated flow points at previous crossing locations, and adding large wood and in-stream structures to create pools in the straightened channel. The addition of large wood will improve the large woody debris score and the in-stream structures will improve the bed form diversity and lateral migration scores (Figure 29). In this example, monitoring of diatoms and macroinvertebrate metrics revealed a slight increase in scores, however, condition scores remained in the functioning at risk range.

FUNCTION BASED PARAMETERS SUMMARY			
Functional Category	Function-Based Parameters	Existing Parameter	Proposed Parameter
Hydrology	Catchment Hydrology		
	Reach Runoff	0.35	0.65
Hydraulics	Floodplain Connectivity	0.82	0.82
	Flow Dynamics	0.85	0.85
Geomorphology	Large Woody Debris	0.00	0.71
	Lateral Migration	0.60	0.80
	Bed Material Characterization		
	Bed Form Diversity	0.17	0.79
	Riparian Vegetation	0.45	0.88
Physicochemical	Temperature		
	Turbidity		
	Diatoms	0.51	0.56
Biology	Macroinvertebrates	0.51	0.59
	Fish	0.78	0.78

*Figure 29: Moderately Active Restoration Approach SQT workbook Example. Red equals not-functioning, yellow equals functioning-at-risk, and green equals functioning.*

### Active Restoration Approach:

In this hypothetical example, the stream reach is in a forested setting like the previous two examples, but the stream has been channelized (800 linear feet in length) and is also incised (i.e., no floodplain connectivity). Riparian vegetation and bed form diversity are not functioning for reasons explained in the previous examples. Lateral migration is also not-functioning because the bank heights are high due to floodplain disconnection and channel incision, which is exacerbated by the lack of riparian vegetation.

This scenario is an example of active restoration because floodplain reconnection is necessary to prevent flood flows from continuing to further erode and widen the channel. The current stream type is a Rosgen Gc, which may evolve into an F through bank erosion and aggradation. The channel will likely evolve back into a C channel after decades of channel evolution. The current stage in the stream evolution model (SEM; Cluer and Thorne 2014) for this incised stream is stage 3 degradation or stage 4 degradation and widening. Eventually the combination of decreased stream power resulting from channel widening and the increased sediment supply from the bank will lead to aggradation and, after decades of channel evolution, the channel will likely evolve to quasi-equilibrium (stage 6).

Significant modification is needed to establish a new meandering channel geometry (1,000 linear feet in length) and reconnect the stream to a floodplain, either by raising the bed and re-meandering the channel or excavating a floodplain. Improvements in parameter scores are shown in Figure 30.

FUNCTION BASED PARAMETERS SUMMARY			
Functional Category	Function-Based Parameters	Existing Parameter	Proposed Parameter
Hydrology	Catchment Hydrology		
	Reach Runoff	0.35	0.65
Hydraulics	Floodplain Connectivity	0.00	0.82
	Flow Dynamics	0.69	0.85
Geomorphology	Large Woody Debris	0.00	0.71
	Lateral Migration	0.60	0.80
	Bed Material Characterization		
	Bed Form Diversity	0.17	0.79
	Riparian Vegetation	0.45	0.88
Physicochemical	Temperature		
	Turbidity		
	Diatoms	0.51	0.56
Biology	Macroinvertebrates	0.51	0.59
	Fish	0.78	0.78

*Figure 30: Active Restoration Approach SQT workbook Example. Red equals not-functioning, yellow equals functioning-at-risk, and green equals functioning.*

Functional lift for each scenario is summarized in Table 13. For the passive and active restoration approaches, the proposed stream length is 1,000 linear feet but for the moderate approach, the channelized stream length remains at 800 linear feet. Even though the proposed condition scores are similar across all three scenarios, the most functional lift was achieved by the active approach because the existing channel in this scenario was in the worst condition. Additionally, greater lift was achieved when all functional categories were monitored instead of only Hydrology, Hydraulics, and Geomorphology, demonstrating the value in monitoring Physicochemical and Biology even if they do not achieve a reference standard condition.

*Table 13: Summary of Restoration Approach Scenarios for two monitoring scenarios, where  $\Delta FF$  is change in functional feet and H&H is Hydrology & Hydraulics.*

Restoration Approach	$\Delta FF$ for H&H and Geomorphology	$\Delta FF$ for H&H, Geomorphology, Physicochemical and Biology
Passive	90	100
Moderate	220	286
Active	300	366

### 3.4 Monitoring

Functional change is predicted using the Quantification Tool worksheet and then verified through monitoring. Monitoring data are entered in the Monitoring Data worksheet (Section 1.2.4).

Monitoring requirements may vary between projects, and thus the monitoring period length, performance standards, and number of monitoring events will be specified by the regulating agency on a project-specific basis. Below are general guidelines for applying the AKSQTint.

Existing Condition – Existing condition field values are **measured** prior to the implementation of restoration activities (e.g., grading, planting, and installation of wood).

- Note: If a field value is entered for a metric in the Existing Condition Assessment, a value **must also be entered** for the same metric in all subsequent condition assessments (proposed, as-built, and every monitoring event).
- For some metrics multiple years of data are required (i.e., fish metrics).
- For other metrics, where only a single sampling event is required, multiple sampling events will improve the accuracy of the field value used to calculate lift by quantifying inter- or intra-annual variability (e.g., macroinvertebrates and physicochemical metrics).

Proposed Condition – Proposed condition field values are **estimated/predicted** using available project data. For mitigation projects, proposed conditions are based on the **expected condition at the end of the project monitoring period** or at mitigation closeout (e.g., year 5, 7 or 10). Bankfull verification and proposed condition field values should be outlined in the restoration or mitigation plan.

As-built – As-built condition should be measured to verify proposed field values following construction for some metrics (listed below). The as-built field values should highlight any changes from the proposed condition.

- Channel plan form should verify pool spacing ratio in meandering streams and the proposed stream length.
- Concentrated flow points, entrenchment ratio, bank height ratio, width/depth ratio, large woody debris frequency, percent streambank armoring, pool spacing ratio, pool depth ratio, and percent riffle metric field values should be measured post-construction to verify proposed condition field values.
- The proposed condition field values for the remaining metrics (land cover metrics, other lateral migration metrics, riparian vegetation cover metrics, and all metrics in the physicochemical and biology functional categories) may not be achieved immediately post-construction and the existing condition field value should be entered for the as-built condition and subsequent monitoring events until post-project data are collected for a particular metric.

Monitoring Events – Monitoring field values are measured at any given point after restoration activities have been completed and data collection should be sufficient to document potential problems in achieving the proposed condition during the monitoring period. The field values that

were predicted during the design phase are also the performance standards.<sup>40</sup> If these field values are not obtained during monitoring and the trend is not towards the predicted value, an adaptive management plan may be needed. The frequency of monitoring different metrics can vary based on the level of effort and expense of the data collection. Monitoring events should occur within the index periods specified for each selected metric, and wherever possible, data collection should occur at a similar time of year for each monitoring event.

- To complete a condition assessment on the Monitoring Data worksheet, the user should first fill in any measured values and then, **for any metrics not assessed, hold the previously measured field value constant.**

Project Closeout – **All metrics should be measured at project** closeout (end of a specified monitoring period). Note that the user should consult with the Corps for guidance if stressors and changes to catchment scale processes are suspected to affect the measured condition at project closeout.

Note that where stressors and changes to catchment scale processes are suspected to affect either the existing or proposed condition scores the user should consult with the Corps or appropriate regulating agency.

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<sup>40</sup> Regulatory agencies may require additional performance standards beyond what is used in the SQT.



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**APPENDIX A:**  
**Field Data Collection Methods for the**  
**AKSQTint**

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## A1. Introduction and Purpose

The purpose of this document is to provide field methods that can be used to collect data for entry into the Stream Quantification Tool and Debit Calculator for the Alaskan Interior (AKSQTint). Few measurements are unique to the AKSQTint, and data collection methods are often detailed in other instruction manuals or literature. Field trainings on these methods (e.g., bed form identification, BEHI/NBS, aquatic AIM field methods, among others), and the Stream Functions Pyramid Framework are recommended to ensure that the methods are executed consistently. Experience requirements for each parameter are provided in the User Manual.

Teams collecting and analyzing these data should have experience and expertise in botany, aquatic ecology, hydrology, and geomorphology as well as experience and expertise applying the assessment methods used to calculate the metrics included in the SQT. **Interdisciplinary teams of at least two people with a combination of these skill sets are necessary to ensure consistent and accurate data collection and analyses.**

This appendix serves as a compliment to Chapter 2 (Pg. 34) of the User Manual, which provides information on how to select parameters, calculate metric field values from field data, and input these values into the AKSQTint and Debit Calculator workbooks.

Field forms that may be useful for data collection are provided in Appendix B and provided for convenience, they are not required. Several of the data forms are also available as Microsoft Excel Workbooks where data can be entered upon returning from the field. There is a shading key on some of the field forms that indicates which cells are to be filled out in the office versus the field, and which cells perform calculations. The calculation cells will automatically calculate values from provided field data in the workbook versions. These cells can also be filled out on a printed field form. Other data processing tools, such as the Mecklenberg Reference Reach Spreadsheet (Mecklenberg 2004) can be used to process field data and calculate metric values.

Prior to going into the field, the user should determine which parameters and metrics will be assessed (refer to Section 2.5 of the User Manual). For evaluating the following parameters and metrics, **users should be familiar with the following methods and should review the following references prior to field sampling.**

**Table A.1:**      *Field methods not included in this document*

Metric or Method	References
<ul style="list-style-type: none"><li>• Large Woody Debris Frequency</li><li>• Percent Fines &lt; 2mm</li><li>• Vegetative Complexity</li><li>• Percent Native Cover</li></ul>	<ul style="list-style-type: none"><li>• BLM (2017)</li></ul>
<ul style="list-style-type: none"><li>• Bank Erosion Hazard Index/Near Bank Stress (BEHI/NBS)</li></ul>	<ul style="list-style-type: none"><li>• Appendix D of Function-Based Rapid Field Stream Assessment Methodology (Starr et al. 2015), or</li><li>• River Stability Field Guide, Second Edition (Rosgen 2014)</li></ul>
<ul style="list-style-type: none"><li>• Physicochemical and Biology metrics</li></ul>	<ul style="list-style-type: none"><li>• Users must be familiar with specific methods cited in the User Manual.</li></ul>

## A2. Field Preparation Information

Parameter selection will dictate how many visits to the project may be necessary to accomplish data collection for all metrics. At a minimum, users should assess hydrology, hydraulics, and geomorphology using the basic suite of parameters. Rapid survey options for field data collection are available for metrics derived from longitudinal profile and cross-section survey data.

### **Equipment List**

At a minimum, the following field gear will be needed:

- Field forms and maps (Rite in the Rain paper)
- Clipboard, pencils, and sharpies
- Waders (breathable)
- Wading boots (no felt bottoms)
- Pin flags (50)
- Roll of flagging
- Camera
- Metric ruler
- 15m tape (or longer, for measuring LWD lengths)
- Calipers or DBH tape (not required, but helpful for the LWD assessment)
- Clinometer (for bank angle measurements of BEHI)
- GPS unit (helpful with lateral migration, riparian extent, and sinuosity field measurements)
- Survey equipment – The rapid field methods in this appendix are for differential-leveling survey methods using a hand level or line level. Other survey methods are acceptable, rapid methods are provided for convenience and not as a requirement. For the methods in this manual, the following gear will be needed:
  - Hand or line level
  - Enough 300' tapes for the assessment reach length (note: a tape with feet on one side and metric on the other is recommended)
  - 100' Tape
  - Stadia rod

### A3. Reach and Representative Sub-Reach Assessments

The following sequence of steps is recommended. Based on parameter selection, not all steps will need to be completed for all projects.

Prior to field work, the user should determine whether the project area should be delineated into multiple project reaches (see Section 2.1 of the User Manual, Pg. 36). When multiple project reaches exist on the same stream, data collection typically proceeds from upstream to downstream. However, if biological sampling is being performed, evaluate the most downstream reach first and work upstream or collect biological samples prior to other instream work to avoid muddy waters and impacted samples.

#### **Procedure**

1. Conduct necessary pre-field desktop activities; review Chapter 2 of the User Manual. For each reach users should review available information and prepare a list of action items for the field to:
  - a. Determine reference stream type,
  - b. Complete the catchment assessment,
  - c. Complete the Site Information and Reference Selection section of the Quantification Tool (and the **Project Reach form**, if used),
  - d. Verify bankfull, and
  - e. Collect all field data for applicable/selected metrics.
2. Walk along the stream throughout the project area to verify the delineation of project reaches. Determine whether additional segmentation is needed based on field conditions. Record the GPS location at the upstream and downstream ends of each reach.
3. Within each project reach, walk along the stream length to view locations and character of riffles, the number of concentrated flow points, length of armoring, presence of beaver dams or other impoundments, and bankfull indicators. This data can be recorded in the **Project Reach form**.
  - a. Measure difference between bankfull stage and water surface elevation at multiple points along the project reach. Use this data to come to a consensus on the difference between the bankfull (BKF) elevation and water surface (WS) elevation. If the channel does not have water, use the edge of channel in riffles as a surrogate for water, but avoid scour areas and bars. Note, this method will create more variability in the measurement.
  - b. Consider possible locations for the stable riffle cross-section (described in Section 2.6.1 of the User Manual). The preference is for the riffle to be located within the project reach. However, in disturbed settings, this cross-section may be located upstream or downstream of the reach.
  - c. Record number of concentrated flow points and length of any armored sections of bank. Instructions for these metrics are provided in Chapter 2 of the User Manual.

- d. Measure sinuosity (Sinuosity section below).
4. Select the location within the reach for biological sampling (if applicable).
5. Sample macroinvertebrates in accordance with BLM Technical Reference 1735-2, *AIM National Aquatic Monitoring Framework: Field Protocol for Wadeable Lotic Systems* (BLM 2017). Processed samples should be immediately preserved with ethanol or other appropriate preservative, and stored in a cool, shaded area for the remainder of data collection.
6. Sample diatoms; refer to ENRI's protocol adopted from U.S. EPA Methods and summarized in Rinella and Bogan (2007).
7. If the project reach is long, determine the location of the representative sub-reach. Record the GPS location at the upstream and downstream ends of the representative sub-reach.
  - a. Measurements from the representative sub-reach will quantify floodplain connectivity, flow dynamics, large woody debris, lateral migration (except armoring), bed material characterization, bed form diversity, and riparian vegetation parameters.
  - b. The representative sub-reach should be at least 20 times the bankfull width or two meander wavelengths (Leopold 1994), whichever is longer. If the entire reach is shorter than 20 times the bankfull width, then the entire project reach should be assessed. Record the length of the representative sub-reach.
8. Survey the stable riffle cross-section (see Rapid Riffle Survey methods below). If applicable, locate the cross-section in a portion of the riffle not substantially disturbed by biological sampling.
9. Conduct a longitudinal profile for bed form diversity and floodplain connectivity data; Rapid survey methods are provided below in Section A5.
  - a. Survey additional riffle cross-sections as needed to quantify width/depth ratio and entrenchment ratio within the representative sub-reach (see Rapid Riffle Survey section below).
10. Perform dominant BEHI/NBS measurements throughout the representative sub-reach. A field form is provided for convenience in Appendix B.
11. Establish transects and conduct a large woody debris assessment, bed material characterization, and riparian vegetation surveys, as applicable based on parameter selection. Refer to User Manual and BLM TR 1735-2 (BLM 2017). Field forms are provided for convenience in Appendix B.
12. Install temperature sensors and turbidity loggers as applicable based on parameter selection.

### **Sinuosity**

The sinuosity of a stream is calculated by dividing the channel distance by the straight-line valley length between the upstream and downstream extent of the project reach (measure the full project reach length rather than the representative sub-reach). Sinuosity can be calculated

from recent aerial imagery, if available. **If recent aerial imagery is not available or the stream channel is not visible in the imagery, then sinuosity should be measured in the field.**

**Method:**

1. Measure the stream length for the entire project reach using a tape along the edge of channel, GPS, or aerial imagery.
2. Measure a straight line following the fall-line of the valley using a tape, range finder, GPS, or aerial imagery.
3. The stream length divided by the valley length equals sinuosity. This value can be recorded on the **Project Reach form**.

**Rapid Riffle Survey**

Riffle cross-sections are used for multiple purposes in the SQT, select riffle(s) and locations as applicable according to the instructions summarized below and in the User Manual.

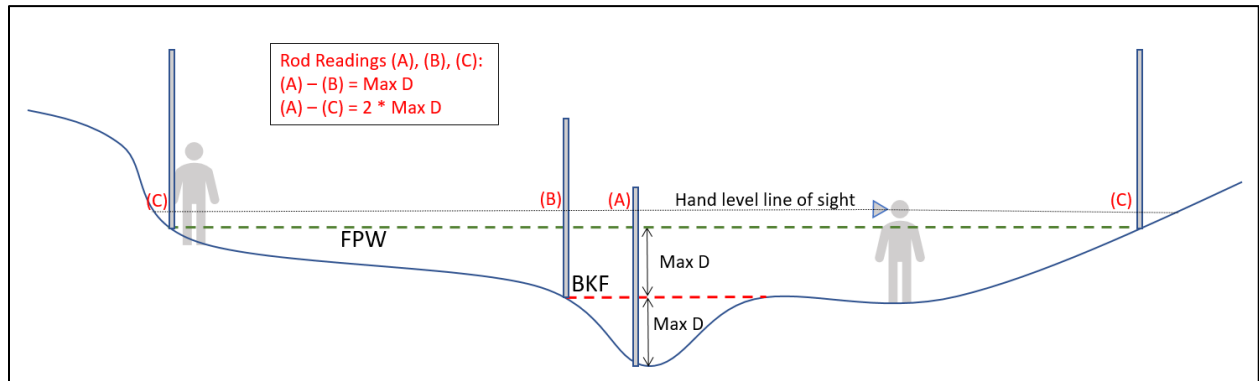
- Stable Riffle, described in Section 2.6.1 of the User Manual (Pg. 59), is a stable riffle that is used for *bankfull verification*. Dimensions from this riffle also provide the denominator for the pool spacing and pool depth ratios. Stable riffle data from the rapid method can be recorded on the **Project Reach form**.
- At least one riffle cross-section is needed to determine to the *existing stream type* of the project reach. This riffle should be located in the representative sub-reach and provide measurements for the entrenchment ratio metric field value where flood-prone width is uniform (as verified using topographic data).
- The bank height ratio and width/depth ratio are required at every riffle in the representative sub-reach to quantify floodplain connectivity and flow dynamics. These data can be collected from cross-sections at the center of each riffle or from the riffle data collected for the longitudinal survey (see Section A5).

**Method:**

1. Determine the location of the cross-section within the riffle. Make sure that the cross-section is perpendicular to the direction of flow at bankfull.
2. Stretch a tape from the left bankfull indicator to the right bankfull indicator. Use the primary bankfull indicator or the difference between water surface elevation from the reach walk.
3. Record the bankfull width.
4. Level the tape by attaching a line level or by measuring the distance from the water surface to the tape at the left and right edge of water surface; the location where the water meets the streambank. The distance should be the same on both sides.
5. Working from left to right, record the station from the tape and the depth from the tape to the ground using a stadia rod. Include bankfull, major breaks in slope, edge of channel, water surface, the thalweg, and other points along the channel bottom.



6. Identify the flood-prone elevation (e.g., relative elevation or stadia rod reading) and measure the flood-prone width (FPW) as shown in Figure A.1. The flood-prone width should be measured perpendicular to the fall line of the valley. The FPW can be measured using a tape, range finder, or GPS.



**Figure A.1: Surveying Flood Prone Width**

For the stable riffle, space is provided on the **Project Reach form** to calculate the bankfull mean depth and cross-sectional area. These calculations are automatically performed in the Microsoft Excel Workbook version of the **Project Reach form**. A rough estimate of the mean depth can be calculated by adding all the depth measurements (except for zeros at bankfull) and dividing by the number of observations. Compare the bankfull width, mean depth, and area to the regional curve values on the field form.

## A4. Bed Feature Identification

Bed forms include the various channel features that maintain heterogeneity and stability in the channel form, including riffles, runs, pools, and glides (Rosgen 2014). Together, these bed features create important channel patterns and habitats for aquatic life. Riffles and pool types are defined in this section.

**Riffles** are shallow, steep-gradient channel segments typically located between pools. Riffles are the river's natural grade control feature (Knighton 1998) and are sometimes referred to as fast-water channel units (Hawkins et al. 1993; Montgomery and Buffington 1998). For purposes of the AKSQTint, in meandering streams riffles broadly represent the section between lateral-scour pools known as a **crossover**, regardless of bed material size. The term riffle also refers to ripples in sand bed streams and the cascade section of steep mountain streams. For the percent riffle metric in the SQT, riffles are measured from head of riffle to head of significant pool. The SQT does not distinguish run features from riffles, runs are considered riffles and similarly glides are considered pools.

**Ripples** are small-scale bed forms in sand bed channels. As sand accumulates and the size of the ripple grows, it becomes a dune. Other sand-bed forms include plane beds and anti-dunes (Knighton 1998).

The SQT requires identification of two pool types: **geomorphic pools** and **significant pools**. Guidance for identifying pools in different valley types is provided below. **Note: Pool identification is slightly different for pool spacing than it is for pool depth and percent riffle metrics.** Guidance on pool identification for each metric is provided under each metric's description.

**Geomorphic pools** are associated with planform features that create large pools that remain intact over many years and flow conditions. These pools are associated with the outside of a meander bend (streams in alluvial valleys) and downstream of a large cascade or step (streams in colluvial valleys). These pools are used exclusively with the pool spacing ratio metric.

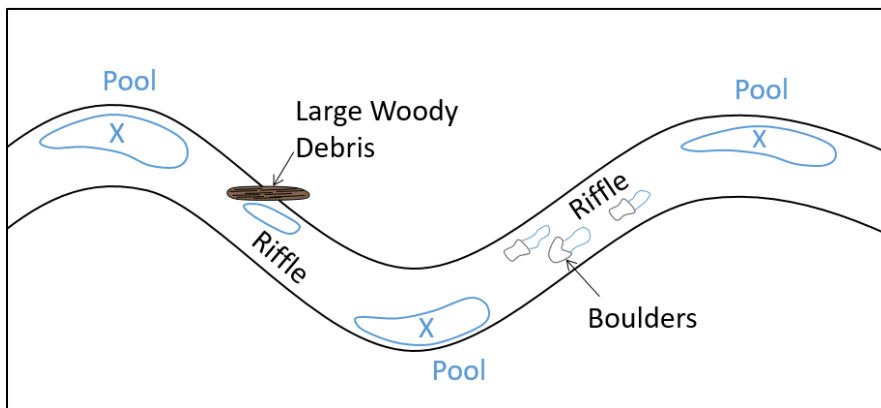
**Significant pools** are geomorphic pools (see above) AND pools associated with wood, boulders, convergence, and backwater in the main channel. Significant pools are contained within the main channel; contain the thalweg; are laterally and longitudinally concave; and span at least 50% of the wetted channel at any location within the pool. Significant pools are used in calculating the pool depth ratio and percent riffle metrics.

Pools that do not meet the criteria for significant pools are sometimes called micro-pools. Micro-pools are small and may not last for a long period of time or after a large flow event. Micro-pools can be found in riffles and cascades. An example is a scour pool downstream of a single piece of large woody debris. **Micro-pools are never counted as pools in the SQT.**

### Identifying Geomorphic Pools in Alluvial-Valley Streams:

Geomorphic pools in alluvial valleys are located along the outside of the meander bend. Figure A.2 provides an illustration of what is and is not counted as a geomorphic pool (pools counted are marked with an 'X'). The figure illustrates a meandering stream, where the pools located in the outside of the meander bend are counted for the pool spacing measurement, and the 'X' marks the approximate location of the deepest part of the pool. The pools associated with the

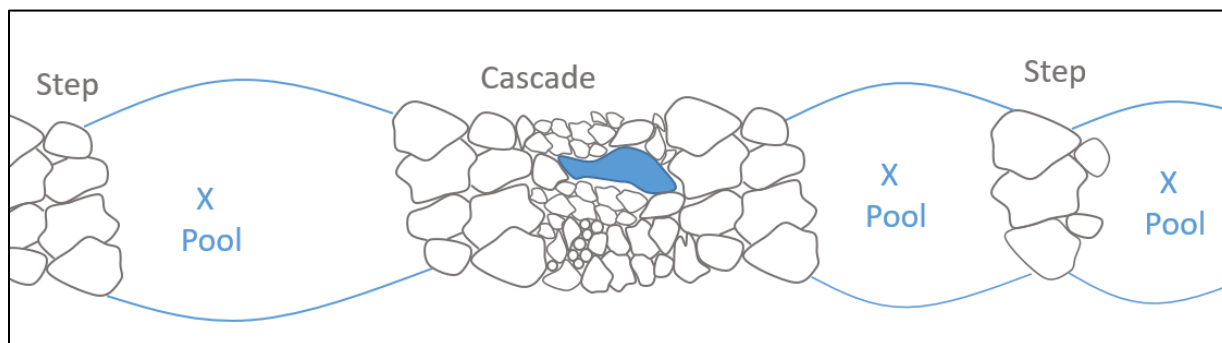
large woody debris and boulder clusters in this figure are not counted because they are micro-pools. Compound pools that are not separated by a riffle within the same bend are treated as one pool. However, compound bends with two pools separated by a riffle are treated as two pools. Rosgen (2014) provides illustrations for these scenarios.



**Figure A.2: Pool Spacing in Alluvial Valley Streams**

#### **Identifying Geomorphic Pools in Colluvial and V-Shaped Valleys:**

Pools in colluvial or v-shaped valleys should only be counted as geomorphic pools if they are downstream of a step, riffle, or cascade. Micro-pools within a riffle or cascade are not counted, just like pools within a riffle of a meandering stream are not counted. An example of pool spacing in a colluvial or v-shaped valley is shown in Figure A.3. For these bed forms, pools are only counted at the downstream end of the riffle or cascade; micro-pools within the feature are not included.



**Figure A.3: Pool Spacing in Colluvial and V-Shaped Valleys**

## A5. Rapid Survey

This section outlines rapid survey methods to collect data to inform floodplain connectivity, flow dynamics, and bed form diversity parameters. The rapid survey techniques for collecting these data are considered more rapid than surveying the longitudinal profile and cross-sections. These methods require little post-processing of the field data. Survey methods described in this appendix are provided for convenience, recognizing that other standard survey techniques that collect accurate location and elevation data are acceptable and can be used to calculate metric field values.

The Rapid Survey form is provided in Appendix B. There is a shading key on the field form that indicates which cells are intended to be filled out in the office versus the field, and which sections are for performing field calculations. The calculation cells can be filled out on a printed field form. In the workbook version, these cells will automatically calculate values from provided field data. Field values that can be entered directly into the Quantification Tool worksheet from this field form are bolded. These include: weighted BHR, weighted ER, weighted W/D, percent riffle, average pool depth ratio, and median pool spacing ratio.

### Method:

1. Establish a representative sub-reach within the project reach.
  - a. Measurements from the representative sub-reach will quantify floodplain connectivity, flow dynamics, large woody debris, lateral migration (except armoring), bed material characterization, bed form diversity, and riparian vegetation parameters.
  - b. The representative sub-reach should be at least 20 times the bankfull width or two meander wavelengths (Leopold 1994), whichever is longer. If the entire reach is shorter than 20 times the bankfull width, then the entire project reach should be assessed.
2. Beginning at the upstream end of the sub-reach, stretch tape(s) along either the left or right bank as close to the edge of the channel as possible, threading them through riparian vegetation or other obstructions if necessary. Tape(s) can be secured to the ground with range pins, vegetation, or rocks. Stationing of features will be obtained from the tape. Begin and end the representative sub-reach at the head of a riffle feature.
3. Record sub-reach length in the **Rapid Survey form**.
4. Measure the slope of the sub-reach (see Reach Slope section below).
5. Working from upstream to downstream, take measurements at every riffle and pool within the sub-reach using a stadia rod and a hand level. A line level can be used instead of a hand level for small streams. NOTE: Review pool identification instructions provided in Section A4.
  - a. Measure the following at every riffle within the sub-reach and record values in the **Rapid Survey form**. These data are used to calculate the bank height ratio, entrenchment ratio (if applicable), width/depth ratio, and percent riffle metrics.

- i. Measure the length of the riffle, including runs, if present. Riffle length is measured by taking a station reading from the tape at the head (beginning) of the riffle and another station reading downstream at the head of a **significant pool**.
- ii. Identify the middle of the riffle feature and bankfull elevation.
- iii. From mid-riffle, measure the difference in stadia rod readings from the thalweg to the top of the lower of the two streambanks. Record this value as the Low Bank Height on the **Rapid Survey form**. The low bank height is the lower of the left and right streambanks, indicating the minimum water depth necessary to inundate the floodplain.
- iv. From mid-riffle, measure the difference in stadia rod readings from the thalweg to the bankfull elevation, and record this value as the bankfull maximum depth on the **Rapid Survey form**. Alternatively, measure the difference in stadia rod readings from the thalweg to the water surface then add the value recorded for the difference between bankfull stage and water surface.
- v. From mid-riffle, measure the difference in stadia rod readings from the edge of channel, which is the breakpoint between the streambed and streambank, to the bankfull elevation, and record this value as the mean depth on the **Rapid Survey form**. Alternatively, measure the difference in stadia rod readings from the edge of channel to the water surface then add the value recorded for the difference between bankfull stage and water surface.

Note: Using the edge of channel up to the bankfull elevation measurement as an estimate of mean depth works best in streams where the thalweg is close to the middle of the channel. If scour or large sediment deposits are at the edge of the channel, this method should not be used. An alternative approach in this case is to measure multiple bankfull depths across the channel (refer to Rapid Riffle Survey instructions in Section A3), average the depths, and record this value as the mean depth on the **Rapid Survey form**.

- vi. From mid-riffle, measure the bankfull width and record this on the **Rapid Survey form**.
  - vii. Flood-prone width should also be measured at each riffle in sub-reaches with changes in valley width or a bank height ratio near, or greater than, 2.0. At mid-riffle, locate and flag the point along the cross-section in the floodplain where the difference in stadia rod readings between the thalweg and that point is twice that of the bankfull maximum depth (see Figure A.1 for illustration). Record flood-prone width on the **Rapid Survey form**.
- b. Identify pools within the sub-reach. Refer to pool definitions in Section A4 of this appendix for geomorphic and significant pools.
  - c. Measure the following at every pool within the sub-reach and record values in the **Rapid Survey form**. These data are used to calculate the pool spacing and pool depth ratio metrics.
    - i. When applicable, identify the pool as a geomorphic pool.

- ii. Determine the deepest point of the pool and record the station.
- iii. Measure the maximum pool depth by placing the stadia rod at the deepest point in the pool and recording the depth **to bankfull elevation**. Alternatively, measure the difference in stadia rod readings from the deepest point in the pool to the water surface and then add the value recorded for the difference between bankfull stage and water surface.

### **Reach Slope**

Average reach slope is part of stream classification and metric stratification. It is not used as a function-based parameter or metric.

#### **Method:**

1. Take a stadia rod reading of the water surface elevation at the head of the first riffle and the head of the last riffle in the representative sub-reach. If limited by the line of sight and/or magnification of the hand level being used, take a stadia rod reading of the water surface elevation at the head of the first riffle and the head of the last riffle within a line of sight. Repeat as needed throughout the project reach making sure that the total drop in elevation is recorded.

Note, for reaches with a consistent slope (i.e., pool slope and riffle slope are similar), a relatively short length of channel can be measured. For streams with large slope changes between riffles and pools, the entire sub-reach should be measured. Using a hand level to calculate slope is prone to large errors. It is preferable to use a laser level to calculate slope if one is available.

2. Calculate the difference in stadia rod readings, divide the difference in stadia rod readings by the channel length between these two points. Where multiple readings were taken, the sum of the elevation changes should be used in the numerator (total fall over the measured length). The denominator is the total stream length between the first and last measurement point. Space is available for calculations in the **Project Reach form**.



## **APPENDIX B:**

### **Optional Field Forms**

1. Project Reach Form
2. Rapid Survey Form
3. Large Wood Form
4. Lateral Migration Form
5. Substrate Form
6. Veg Form
7. Nonnative Veg Form

Date:  
Investigators:

**I. Site Information**

Project Name:	
Reach ID:	
Drainage Area (sq. mi.):	
Flow Type:	
Stream Order:	
Valley Type:	
Stream Reach length (ft):	
Latitude:	
Longitude:	

Shading Key
Desktop Value
Field Value
Calculation

**II. Reach Walk**

A.	Difference between bankfull (BKF) stage and water surface (WS) (ft)							
	Difference between BKF stage and WS (ft) <i>Average or consensus value from reach walk.</i>							
B.	Number Concentrated Flow Points							
	Concentrated Flow Points/ 1,000 L.F.							
C.	Length of Armoring on banks (ft)							
	Total (ft)							
	Percent Armoring (%)							
D.	Valley length (ft)							
	Stream Length (ft)							
	Sinuosity							

**III. Identification of Representative Sub-Reach**

Representative Sub-Reach Length At least 20 x the Bankfull Width		20*Bankfull Width	
Latitude of downstream extent:			
Longitude of downstream extent:			

**Sub-Reach Survey Method**

- ☐ Longitudinal Profile & Cross Section  
☐ Rapid Survey

Date:  
Investigators:

**IV. Bankfull Verification and Stable Riffle Cross-section**

Is Cross-section located within Representative Sub-Reach?

☐ Yes ☐ No

If no, explain why:

A.	Bankfull Width (ft)	
B.	Bankfull Mean Depth (ft) = Average of cross-section depths	
C.	Bankfull Area (sq. ft.) Width * Mean Depth	
D.	Regional Curve Bankfull Width (ft)	
E.	Regional Curve Bankfull Mean Depth (ft)	
F.	Regional Curve Bankfull Area (sq. ft.)	
G.	Curve Used	

Cross-section Measurements Depth measured from bankfull			
Station	Depth	Station	Depth

**V. Stream Classification of Stable Riffle**

A.	Width/Depth Ratio (ft/ft) Bankfull Width / Bankfull Mean Depth	
B.	Bankfull Max Riffle Depth	
C.	Floodprone Area Width (ft)	
D.	Entrenchment Ratio (ft/ft) Floodprone Area Width / Bankfull Width	
E.	Slope Estimate (%)	
F.	Channel Material Estimate	
G.	Stream Type	

Date:  
Investigators:

VI.

Representative Sub-Reach Sketch

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VIII.

Notes

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Date:  
Investigators:  
Reach ID:

**I. Riffle Data (Floodplain Connectivity & Bed Form Diversity)**

A.	Representative Sub-Reach Length			20*Bankfull Width	
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**B. Bank Height & Riffle Data: Record for each riffle in the Sub-Reach**

	R1	R2	R3	R4	R5	R6	R7	R8
Begin Station								
End Station								
Low Bank Height (ft)								
BKF Max Depth (ft)								
BKF Mean Depth (ft)								
BKF Width (ft)								
Flood Prone Width (ft)								
Riffle Length (ft) <i>Including Run</i>								
Bank Height Ratio (BHR) Low Bank H / BKF Max D								
BHR * Riffle Length (ft)								
Entrenchment Ratio (ER)								
ER * Riffle Length (ft)								
W/D BKF Width/BKF Mean Depth								
W/D * Riffle Length (ft)								

C.	Total Riffle Length (ft) <i>Excludes Additional Pool Lengths</i>	
D.	<b>Weighted BHR</b> $\frac{\sum(Bank\ Height\ Ratio_i \times Riffle\ Length_i)}{\sum Riffle\ Length}$	
E.	<b>Weighted ER</b>	
F.	<b>Weighted W/D</b>	
G.	<b>Percent Riffle (%)</b>	

Shading Key
Field Value
Calculation

Date:  
Investigators:

**II. Pool Data (Bed Form Diversity)**

A. Pool Data: Record for each pool within the Sub-Reach

	P1	P2	P3	P4	P5	P6	P7	P8
Geomorphic Pool?								
Station								
P-P Spacing (ft)	X							
Pool Spacing Ratio Pool Spacing/BKF Width	X							
Pool Depth (ft) Measured from BKF								
Pool Depth Ratio Pool Depth/BKF Mean Depth								

B. **Average Pool Depth Ratio**

C. **Median Pool Spacing Ratio**

**III. Slope**

	Begin	End	Difference	Slope (ft/ft)
Station along tape (ft)				
Stadia Rod Reading (ft)				

**IV. Notes**



Date:

Investigators:

AKSQTint v1.0

Large Wood Form

Large Wood				
Fill in if unmarked boxes are zero				
Diameter at large end	Pieces All/Part In Bankfull			
	1.5-3m	3-5m	5-15m	>15m
0.1-<0.3m				
0.3-0.6m				
0.6-0.8m				
>0.8m				
Diameter at large end	Pieces Above Bankfull			
	1.5-3m	3-5m	5-15m	>15m
0.1-<0.3m				
0.3-0.6m				
0.6-0.8m				
>0.8m				

Notes:

**AKSQTint v1.0**

## Lateral Migration Form

Valley Type:

### Bank Erosion Hazard Index

Date:

Investigators:

Summary Table

BEHI/NBS Ranking	Enter bank Length from all rows on p.1 with same ranking									Length (Feet)	Percent of Total
Ex/Ex											
Ex/VH											
Ex/H											
Ex/M											
Ex/L											
Ex/VL											
VH/Ex											
Vh/VH											
VH/H											
VH/M											
VH/L											
VH/VL											
H/Ex											
H/VH											
H/H											
H/M											
H/L											
H/VL											
M/Ex											
M/VH											
M/H											
M/M											
M/L											
M/VL											
L/Ex											
L/VH											
L/H											
L/M											
L/L											
L/VL											
Total Length:											
Eroding Length:											

Date:  
Investigators:

Transect		Point ID					
Main Transect - Substrate				Mid Transect - Substrate			
% Dist LB	Size^	Location ?	Flag/Comments	% Dist LB	Size^	Location ?	Flag/Comments
5				5			
15				15			
25				25			
35				35			
45				45			
55				55			
65				65			
75				75			
85				85			
95				95			
		add wet or dry-mid				add wet or dry-mid	
		add wet or dry-mid				add wet or dry-mid	
		add wet or dry-mid				add wet or dry-mid	
		add wet or dry-mid				add wet or dry-mid	
		add wet or dry-mid				add wet or dry-mid	

Flags: N = Not collected, E = Estimated

Substrate Location ?	Substrate Non-Meas. Size ^	Dry Transect?	
wet, dry-mid, dry-edge	FN = Fines	Y	N
	SN = Sand		
	HP = Hardpan	Side Channel?	
	BR = Bedrock	Y	N
	Major	Minor	Dry
		Left of main,	Right of main

Transect		Point ID					
Main Transect - Substrate				Mid Transect - Substrate			
% Dist LB	Size^	Location ?	Flag/Comments	% Dist LB	Size^	Location ?	Flag/Comments
5				5			
15				15			
25				25			
35				35			
45				45			
55				55			
65				65			
75				75			
85				85			
95				95			
		add wet or dry-mid				add wet or dry-mid	
		add wet or dry-mid				add wet or dry-mid	
		add wet or dry-mid				add wet or dry-mid	
		add wet or dry-mid				add wet or dry-mid	
		add wet or dry-mid				add wet or dry-mid	



[illegible]

## APPENDIX C:

### Example Impact Activities and Associated Impact Severity Tiers

The purpose of this appendix is to provide examples for consideration when determining the appropriate impact severity tier for a proposed impact activity. These are not rules and should not be used as such. Users must assess each project reach individually and consider which stream functions are being impacted, and to what degree, to determine which Tier the proposed activity would fall into.

The following example activities are included in this appendix:

1. Bioengineered bank stabilization
2. Bioengineered bank stabilization with root wads
3. Bioengineered bank stabilization with riprap toe protection
4. Vegetation stabilization with in-stream structures (barbs, XV, J-hooks, weirs)
5. Bank armoring with riprap, gabions or bulkheads
6. Guide banks and spur dikes
7. Full span bridge
8. Bridge with piers and abutments within 2-year floodplain
9. Bridge stabilized with riprap in channel (armored bed and banks)
10. Stream simulation culverts
11. Embedded hydraulic design culverts
12. Culverts substantially altering channel characteristics
13. Stream channelization

#### Definition

**Ordinary high water mark** (Source: 33 CFR 328 and 33 CFR 329) means that line on the shore established by the fluctuations of water and indicated by physical characteristics such as: a clear, natural line impressed on the bank; shelving; changes in the character of soil; destruction of terrestrial vegetation; the presence of litter and debris; or other appropriate means that consider the characteristics of the surrounding areas.

**Bankfull discharge** is the flow that forms, maintains, and shapes the dimensions of the channel as it exists under the current climatic regime. The bankfull stage or elevation represents the break point between channel formation and floodplain processes (Wolman and Leopold 1957). Refer to Section 2.6 of the User Manual for more information on identifying and verifying bankfull.



**1. Bioengineered bank stabilization<sup>1</sup>** – The use of degradable materials plus necessary anchors to temporarily reduce bank erosion and facilitate vegetation establishment. Materials may reduce near-bank velocity (e.g., spruce tree revetment and brush mattress) or are themselves more resistant to erosion than bare soil (e.g., coir logs, Geotech fabrics, sod mats and river rock). Organic materials will degrade over time. The technique may limit but does not prevent lateral channel migration. Bioengineered bank stabilization helps restore bank stability without adversely affecting any of the stream function parameters. It would have the potential to reduce percent streambank erosion without increasing percent streambank armoring. This type of project has the potential to temporarily remove existing riparian vegetation. However, reduced erosion, along with planted and natural regrowth of native cover and possible improved vegetative complexity, with associated improvements to temperature and turbidity, would benefit macroinvertebrates and fish. Due to the lack of impacts to stream parameters, bioengineered bank stabilization would be in Tier 0.

**2. Bioengineered bank stabilization with root wads<sup>2</sup>** – The installation of root wads to provide toe protection for bank revegetation where erosion risk is high due to a high or vertical bank or location on an outside bend. The primary goal of root wads is to stabilize the banks and to minimize lateral channel migration. This technique protects the toe-of-slope, reducing the rate of streambank erosion but increases the amount of streambank armoring. When installed correctly, this type of armoring provides fish habitat, especially for juveniles and would not be expected to have a significant impact on diatom and macroinvertebrate communities. Appropriate revegetation with native species would occur above the root wads. Root wads provide toe support for bank revegetation techniques and collect sediment and debris that will enhance bank structure over time. Bioengineered bank stabilization with root wads would be in Tier 1.

**3. Bioengineered bank stabilization with riprap toe protection** – The purpose of this technique is to stabilize the bank and reduce lateral channel migration. Riprap is installed below mean low water up to ordinary high water (OHW). The riprap can be interspersed with brush layering and/or live staking. Above OHW, additional vegetation planting would occur. The placement of riprap below OHW and the associated changes in velocity would affect bed form diversity. This technique affects flow dynamics due to the placement of the riprap (narrowing and possibly deepening the channel), decreasing the rate of streambank erosion while increasing the amount of streambank armoring within the reach. This type of project could have minor to severe impacts on aquatic communities, depending on how it is constructed. Adding additional vegetation above the riprap could maintain, increase or decrease the amount of native cover, depending on the species used and the methods and success of the revegetation. This technique could be in Tiers 2, 3 or 4, depending on how it is constructed.

**4. Vegetation stabilization with in-stream structures (barbs, XV, J-hooks, weirs)** – These activities commonly reshape the bank to stabilize the channel with living vegetation and large woody debris. Additionally, hard structures are constructed within the channel, below OHW, that redirect the flow away from the bank and encourage sediment deposition along the bank. This technique intentionally minimizes lateral channel migration to prevent the bank from

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<sup>1</sup> Muhlberg and Moore, 1998. Streambank Revegetation and Protection: a guide for Alaska

<sup>2</sup> Muhlberg and Moore, 1998. Streambank Revegetation and Protection: a guide for Alaska  
(<http://www.adfg.alaska.gov/index.cfm?adfg=streambankprotection.rootwad>)

eroding further. Existing riparian vegetation would be affected during the construction of the project. Changes in flow and the accumulation of sediment around the structure (as well as the structure itself) would affect bedform diversity and flow dynamics. The extent of the riparian vegetation would be altered, however, depending on the type of structure and how it is installed, riparian vegetation could recover or be restored as part of the project. Minor impacts to aquatic communities would be expected. This technique would typically be considered Tier 2, depending on the extent of the project and how it is constructed.

**5. Bank armoring with riprap, gabions or bulkheads** – Replacing the natural bank with materials that resist erosion and provide structural integrity. These techniques extend above OHW and below mean low water and may include riprap covering part of the channel bed. This also includes projects that have a launching riprap component. These techniques are designed to withstand the forces/processes causing bank failure. They intentionally harden the bank in order to prevent the bank from eroding further and affect flow dynamics due to the placement of the riprap (narrowing and deepening the channel). Gabions or bulkheads have more severe impacts to flow dynamics than riprap as these methods create a vertical bank and have less roughness. Near-bank velocity is often increased, leading to increased erosion downstream of the armoring. If the installed riprap raises the bank height, there will be impacts to floodplain connectivity. This project would impact lateral migration by pinning one bank in place. It would decrease streambank erosion rates while increasing the amount of streambank armoring within the reach. Riprap placement in the channel and bed, with associated increases in velocities along the riprap, would impact bed form diversity. The placement of riprap and increased bank height would eradicate riparian vegetation. These techniques would cause moderate impacts to aquatic communities. This technique could be in Tiers, 2, 3 or 4, depending on how constructed.

**6. Guide banks and spur dikes** – Armored fill structures on the stream bed extending above OHW intended to alter flow vectors and velocities to induce sediment deposition immediately downstream of the structure. These structures measurably alter reach hydraulics and may increase bed and bank erosion downstream of the deposition area. Guide banks are typically installed upstream of stream crossings that are narrower than the bankfull width to prevent erosion flanking. Spur dikes limit lateral channel migration within their immediate zone of influence but may increase bank erosion and channel migration further downstream. Spur dikes may be a Tier 3. Guide banks would be a Tier 4 if combined with a Tier 4 stream crossing.

**7. Full span bridge** – These bridges are constructed with abutments set back from the bank (outside of the 2-year floodplain) and have no piers or riprap in the channel. The channel cross-section and floodplain connectivity are maintained. This would have little to no impacts on flow dynamics and bedform diversity since there are no changes to or within the channel itself. Full-span bridges would allow channel maintenance flows to occur unimpeded and would allow some lateral migration. Bridge approaches could impact floodplain and riparian function by removing riparian vegetation and impeding the downgradient conveyance of overbank flows. The longer the span without supports, the fewer impacts on channel functions and aquatic communities. Full-span bridges would be in Tiers 2 or 3, depending upon how much floodplain is spanned and how much riparian vegetation is impacted.

**8. Bridge with piers and abutments within 2-year floodplain** – These bridges would have a much greater impact on the channel than a full span bridge because they contain abutments within the 2-year floodplain and may include piers in the channel. Abutments stabilized with riprap would eliminate riparian vegetation. Piers in the channel impact bed form diversity by creating patterns of degradation and aggradation that are outside the normal range of variability. If abutments and piers constrict flow, velocity within the channel increases, which can cause erosion adjacent to the piers and abutments. The greater the impacts pier and abutment construction cause to the active channel, the greater the impacts to flow dynamics, lateral migration, bed form diversity, aquatic communities, and riparian vegetation will be. At high flows, a narrow bridge opening can create a backwater effect upstream of the bridge impacting hydraulics and geomorphology functions. Bridge approaches could impact floodplain and riparian function by removing riparian vegetation and impeding the downgradient conveyance of overbank flows. If water is redirected back to the channel at higher flows, channel velocities and shear forces would increase. This has the potential to affect aquatic communities depending on the flow velocity under the bridge. Moderate to severe impacts to aquatic communities could occur. Bridges with piers and abutments within the 2-year floodplain would be in Tier 3 or 4 depending on location of abutments, number and location of piers, and amount of riprap used.

**9. Bridge stabilized with riprap in channel (armored bed and banks)** – Bridge abutments stabilized with riprap, where all-natural channel characteristics under the bridge are removed (i.e. riprap is used to armor bed and banks) results in major impacts to lateral channel migration, bedform diversity, riparian vegetation, flow dynamics, and floodplain connectivity. Bridge approaches will likely impact floodplain connectivity and inundation, the deposition of sediments and debris, maintenance of vegetation communities and downgradient flow. For purposes of protecting the bridge structure, riprap is used to pin the channel in place and to prevent any movement, laterally or vertically, of the channel itself. This could result in impacts upstream and downstream of the bridge as well depending on the severity of impacts to flow dynamics and how the riprap channel is constructed. Moderate to severe impacts to aquatic communities could occur. Bridges stabilized with riprap in the channel (armored bed and banks) would be in Tier 4.

**10. Stream simulation culverts<sup>3</sup>** – Culverts that have a greater width than the bankfull channel of the stream (for example  $1.2 \times \text{BKF}W + 2$  feet) and where a channel with an equivalent cross-section is constructed within the culvert. The purpose of stream simulation culverts is to reproduce the chief channel characteristics inside the culvert. The design uses the upstream channel as a reference and copies the slope and bed material. The culvert is sized to allow natural movement of bedload and the formation of a stable streambed inside the culvert. Stream simulation culverts would impact floodplain connectivity but would not eliminate it (since some access to the floodplain above bankfull would be retained). The reduction in floodplain capacity depends on the ratio of natural floodplain width to the floodplain constructed inside the culvert. Normal flow dynamics are maintained for discharges accommodated by the constructed

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<sup>3</sup> Washington Department of Fish and Wildlife's Water Crossing Design Guidelines, 2013

<https://wdfw.wa.gov/sites/default/files/publications/01501/wdfw01501.pdf>

U.S. Fish and Wildlife Service (USFWS). 2020. Culvert design guidelines for ecological function. Revision 5, Feb 5, 2020. U.S. Fish and Wildlife Service, Alaska Fish Passage Program. <https://www.akfishhabitat.org/>

floodplain within the culvert. The addition of overflow culverts to allow for flood plain conveyance is an additional measure that would reduce impacts from impoundments upstream of crossing and degradation downstream of crossing. The installation of a culvert would eliminate riparian vegetation for the length of the culvert. Stream simulation culverts are likely in Tier 3 or possibly Tier 4 depending on the size of the culvert and the quality of the channel reconstruction within the culvert.

**11. Embedded hydraulic design culverts** – Culverts that have a width less than the bankfull channel of the stream and are designed to maintain fish passage at a design high flow and well as at low flow. The substrate material within the culvert should remain dynamically stable up to the 50-year flood, which requires oversized material or retention baffles. The natural channel characteristics are not maintained within the culvert. Hydraulic design culverts would impact floodplain connectivity and floodplain capacity as they do not preserve larger than bankfull channel characteristics. Flow dynamics would be impacted since the channel's width-to-depth ratios would change. Bed form diversity would be impacted to a greater degree than for stream simulation design. Riparian vegetation would be lost. The reach runoff would be impacted. Hydraulic design culverts have the potential to be in Tier 3, but likely are Tier 4, depending on the size of the culvert and if the channel characteristics are recreated within the culvert.

**12. Culverts substantially altering channel characteristics** – Examples include culverts whose invert is not buried, without substrate in the culvert, whose width is insufficient to pass bankfull flow freely/without backwater upstream. Multiple-pipe culvert batteries could be included in this category. This category would also include culverts long enough to eliminate at least one meander bend. Flow dynamics would be impacted because the culverts would change the width-to-depth ratio and replace the channel characteristics with a pipe. This would pin the 'channel' in place and prevent lateral channel migration and would eliminate bedform diversity and riparian vegetation. Of the different types of culvert designs, this would have the greatest potential to impact channel characteristics upstream and downstream of the culvert. Culverts without consideration for stream simulation or fish passage would be in Tier 5, as it would only preserve hydrologic flow and has the potential to impact the channel upstream and downstream of the culvert.

**13. Stream channelization** – Straightening or realigning a stream channel that reduces channel length and typically increases slope. The constructed channel may have a similar cross-section, substrate and floodplain connectivity as the original channel. Floodplain capacity is typically reduced, and flow velocities increased. Bed degradation and disconnection from the floodplain may result. Where the original channel characteristics are substantially altered, impacts would be in Tier 5.

**14. Unimproved low water crossing** – This is a simple stream crossing at the elevation of the streambed without culverts or bridging. An unimproved crossing will rely on the streambed materials to provide the stable surface for vehicle crossing. Impacts to the stream corridor may include removal of riparian vegetation, compaction of soils, and widening of the high-flow cross section to accommodate the approach to the crossing, which could cause bank erosion and sediment deposition. Where vehicle traffic occurs during flow periods, there will be localized impacts on aquatic habitats and localized erosion and release of suspended sediments. These types of crossings would likely be a Tier 1 but may also be a Tier 2 where the timing or volume

of vehicle traffic could affect water quality and aquatic life. Impacts could be higher tier if crossings occur in spawning areas or used during migration periods.

**15. Improved low water crossing** – This is a simple stream crossing at or slightly above the elevation of the stream bed without culverts or bridging. Improved crossings have a stable driving surface composed of rock, concrete, asphalt, concrete blocks, concrete planks, gabions, geocells, or a combination of materials. Sometimes designs include a low-flow channel to pass flows and aquatic organisms. The downstream roadway edge may be stabilized with logs or armored with hard materials (Clarkin et al. 2006). Approaches to the crossing may also be paved and/or ditched. As with unimproved crossings, impacts to the stream corridor may include removal of riparian vegetation, compaction of soils, widening of the high-flow cross section, bank erosion and sediment deposition. Where vehicle traffic occurs during flow periods, there will be localized impacts on aquatic habitats and localized erosion and release of suspended sediments. Where these crossings are constructed above the elevation of the stream bed, additional impacts could include aggradation upstream and localized scour and degradation downstream. Additionally, paved and/or ditched approaches have the potential to concentrate high flows through the crossing, resulting in localized scour and degradation downstream. Any erosion downstream could cause the crossing to become perched, which could impede fish passage and other aquatic life movements. These types of crossings would likely be a Tier 2 or a Tier 3 impact, depending on the design of the crossing in relation to local stream and valley characteristics. Impacts could be higher tier if crossings occur in spawning areas, are used during migration periods, or impede fish passage and aquatic life movement.

## APPENDIX D:

### Recommended Macroinvertebrate Taxonomy Laboratories

The purpose of this appendix is to provide a list of professional laboratories for identification and enumeration of macroinvertebrate samples. Due to known issues with consistency in taxonomy among different labs, it is recommended that a lab that is involved with the BLM AIM program or the EPA NRSA program be contracted for this work, including the following:

1. BLM National Aquatic Monitoring Center (The Buglab)

Department of Watershed Sciences (WATS), Utah State University

5210 Old Main Hill, Logan, UT 84322-5210

(510) 334-9769

<https://www.usu.edu/buglab/>

2. Cole Ecological, Inc.

15 Bank Row, Suite B, Greenfield, MA 01301

(413) 774-5515

[http://www.coleecological.com/Home\\_Page.html](http://www.coleecological.com/Home_Page.html)

3. EcoAnalysts, Inc.

1420 S. Blaine St., Suite 14, Moscow, Idaho 83843

(208) 882-2588

<https://www.ecoanalysts.com/>

4. Lake Superior Research Institute, University of Wisconsin-Superior

Barstow Hall 4, Belknap and Catlin Ave, PO Box 2000, Superior, WI 54880

(715) 394-8160

<https://www.uwsuper.edu/lisri/index.cfm>

5. Rhithron Associates, Inc.

33 Fort Missoula Road, Missoula, Montana 59804

(406) 721-1977

<https://rhithron.com/>